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WRAPPER TOBACCO

By

DOMINGO B. PAGUIRIGAN
Chief, Tobacco Research Section

and

PRIMITIVO TUGADE
Assistant Agronomist

TWENTY-NINE PLATES AND EIGHT TEXT FIGURES

The production of wrapper leaf tobacco has become so specialized a phase of the tobacco industry of the world that it might well be considered a distinct industry by itself. In the past, cigars were wrapped with the same materials used for filler, but the advance of civilization and ensuing refinements in taste made people the world over more critical in their demand for new and better things. At present cigars wrapped with fine, delicate, and light wrappers are in demand. The result is that some countries began to specialize in the production of the desired product, and to-day the Sumatra, the Cuban Havana, the Porto Rican, the Connecticut, and the Georgia wrapper tobaccos are the standard cigar wrappers, produced through highly specialized methods of culture.

The famous Sumatra wrapper, a product of long and painstaking research on acclimatization, breeding, and intensive culture, is arbitrarily accepted as the standard by which all wrapper leaves are judged. The Cubans themselves, notwithstanding the universally high reputation of their "Havanas," admit the

superiority of the Sumatra to their own wrappers. Also, in spite of the world-wide distinction given to the United States cigar wrappers, the American manufacturers prefer the Sumatra for wrapping their high-grade cigars.

Practically in every cigar tobacco country efforts have been made and are being extended towards improving wrapper tobacco and the methods of its production in order to meet the demands and dictates of fashion among smokers.

Many articles have been published in different countries wherein wrapper tobacco is discussed in a greater or lesser degree, but apparently no paper has as yet appeared that is devoted to a general survey of this important industry. This paper, therefore, is to serve principally as a brief yet comprehensive treatise on this subject, with special reference to the point of view of the growers. Its preparation necessitated a thorough search of available literature to bring together many scattered but valuable bits of pertinent information.

It must be stated in passing that this paper is the outcome of an incessant demand for a comprehensive guide on wrapper tobacco culture both in and outside the Philippine Islands. It is hoped that this volume will serve such a purpose.

I. MATERIALS FOR CIGAR MANUFACTURE AND THE SOURCES OF WRAPPER

Leaf materials for cigar manufacture.—In cigar manufacture three distinct tobacco products furnish the materials; namely, the filler, the binder, and the wrapper. The first and the last are specialized products, that is, each is grown specially for the purpose for which it is intended. Filler tobacco, as the word indicates, is raised to form the main body of the cigar. The leaves, therefore, must be of good and rich aroma and of agreeable flavor, and must burn freely and evenly. Binders are used to cover or bind the fillers preparatory to final wrapping. For this purpose usually discarded wrapper or finer filler leaves are used.

The wrapper material is grown specially for wrapping cigars. It must, therefore, be uniform in color and free from holes. It must be very elastic, so that it can be wrapped smoothly and tightly around the cigar. The color must be light, the shape of the leaves almost round, and large enough to yield an optimum number of wrappers per leaf or per weight. It should have the same aroma and flavor as the filler, or, if not

fulfilling this requirement, should at least be neutral so that it will not in any way mar the desirable qualities of the filler. Although the wrapper constitutes but one fifteenth to one twentieth of the cigar, its influence upon the quality of the cigar is very great, apparently on account of its being plain to the view and of its possible effect upon the combustion process. Certain it is that the flavor and aroma of a wrapper is always considered in blending tobacco for high grade cigars. Obviously, therefore, the most important of the three materials is the wrapper. It is the real seller of the cigar. Instinctively, the smoker is first attracted by the outward appearance of the cigar just, as a prospective buyer of a piece of furniture is first attracted by a beautiful finish. In view of this fact and because of the manifold requirements of a standard wrapper, the industry is classified as a specialized phase of the great tobacco industry.

Science has been called in to aid this industry with remarkable results. Experiment stations wholly devoted to research work in tobacco, particularly in wrapper production, have been established. The tobacco experiment station in Medan, Sumatra, the famous island home of the world's best wrapper, is a very good example of the way science is aiding this great industry. The activities of this station are considered to surpass the activities of any similar station elsewhere.

Sources of wrapper.—There are three principal countries supplying the wrapper tobacco of the world, namely:

(*1*) *Sumatra.*—The tobacco trade has accepted the Sumatra wrapper as unquestionably the best and, therefore, the standard of excellence for cigar wrappers. The Sumatra wrapper is produced in the island bearing the same name, a Dutch possession in the East Indies. The United States alone imports about 5,000,000 pounds of Sumatra wrapper yearly. Germany, France, England, the Netherlands, and other European countries are heavy purchasers of Sumatra wrapper tobacco. The Sumatra wrapper is not imported directly from the island of Sumatra but through inscription in Amsterdam and Rotterdam, Holland. Because of the peculiarly adapted soil and the climate of the island, Sumatra tobacco is naturally of a wrapper nature, a character which has been further improved by breeding and selection and by scientific methods of culture. A factor which can not be overlooked is the plentifulness of coolie labor which means that the work can be done entirely by hand. The abundance of land makes intensive agriculture unnecessary. It is claimed that in Sumatra a tobacco field is used only once in seven to twelve years. That is, after it has been cultivated for one season, it is allowed to become nature's garden and is not cleared or used again until seven or twelve years afterwards.

The Sumatra wrapper is an almost tasteless, neutral tobacco as to flavor and, therefore, has an affinity to all kinds of cigar filler. Its further favorable characteristics are its glossy appearance, its highly uniform color, and its remarkable elasticity and fineness. American manufacturers have persisted in the use of Sumarta wrapper in spite of the exhorbitant duty paid for it upon entrance into the United States. The fact that Sumatra never produces filler tobacco and, therefore, does not supply wrapper to any local factories, compels her to produce a quality of wrapper that is universally accepted by importing countries. The outcome is, the creation of the famous Sumatra wrapper which has an affinity to practically all filler tobacco produced in the tobacco producing countries.

(2) *Cuba.*—"Havana" seems to be better known than the term "Cuban" as applied to all tobacco grown on the island of Cuba. Havana as a cigar tobacco, that is, including filler and binder, is considered the finest in the world. Strictly speaking, however, with respect to wrapper, it has not the reputation of the Sumatra. In former years, the Cuban wrapper was produced in the open, but because of the demand for a finer grade the use of the shelter tent was introduced. To-day, the Cuban wrapper is produced almost entirely under shade. Partidos district is claimed to be the most naturally adapted region in Cuba for the production of wrapper. The importation by the United States of Cuban leaf tobacco amounts to about 16,000,000 pounds annually, a great portion of which must be wrapper tobacco.

(3) *United States.*—The Connecticut Valley and the districts of Florida and Georgia are the principal wrapper tobacco regions of the United States. The former raises from 70 to 80 per cent of all the wrapper tobacco produced; Georgia and Florida furnish the rest. Practically all the wrapper tobacco produced in the United States is grown under partial shade. The Connecticut Valley broadleaf and the Havana seedleaf are the only varieties grown for wrapper purposes. The former has a broad silky and very elastic leaf, while the latter, though smaller, is exceedingly thin. The annual production of the United States is from 30,000,000 to 40,000,000 pounds. There was a time when the Sumatra was tried in Florida, but ultimately the growing of this variety was given up because of its inferior characteristics when grown outside its home country. The Florida-grown Sumatra, however, is now cultured in the open as sun-Sumatra strictly for filler purposes.

Miscellaneous sources of wrapper.—Porto Rico has become quite an important wrapper producer lately owing to the introduction of modern methods of culture, specially the use of shelter tents. The United States imports from Porto Rico about 30,000 bales of leaf tobacco annually and no doubt a portion of this is wrapper tobacco. In tropical and semi-tropical countries like Mexico, and the Philippine Islands an appreciable amount of wrapper is obtained from the lower leaves which are thin and glossy due to the shade given by the upper leaves. The supply, however, does not meet the demands of the manu-

facturers with the result that additional wrapper must be imported from the outside, mainly from the United States and Sumatra through Holland.

The United States does not import leaf tobacco for wrapper from the Philippine Islands, but in her importation of cigars and cheroots the products of the Philippine Islands form a large proportion. Philippine cigars, excepting a very limited proportion, are wrapped with native wrappers. High quality Philippine cigars are either wrapped with imported Sumatra or with United States wrapper. Recently, however, the Filipino tobacco growers embarked into the production of purely wrapper tobacco by the use of shelter tents, and in the course of a few years, the country may not only become self-sufficient in her wrapper needs, but may eventually become a wrapper-tobacco exporting country. The existence of ideal soil and climatic conditions coupled with the availableness of suitable varieties for the production of wrapper tobacco in open culture, under more or less humid conditions and in shade culture under more or less droughty conditions, promise a future with bright prospects for the Philippines.

II. CLIMATIC AND SOIL REQUIREMENTS

Climatic requirements.—The production of wrapper tobacco is highly localized. The characteristics which distinguish one type of tobacco from another are primarily the results of a combination of climatic and soil conditions, together with the method of curing and the variety grown in this or in that locality. The various kinds of tobacco demanded by consumers also have a very great effect upon the production of specialized products. These demands are successfully met by the selection of the right locality and the use of persistently progressive methods. Tobacco is one of the most profitable cash crops; for this reason practically every agricultural country has tried to raise it. But while everyone has been and is still trying to employ the same cultural and curing methods and using possibly the same seed or variety, yet the final product is in a general case only typical for this or for that locality where it is produced.

Climate is a great limiting factor. As far as records show, the Sumatra variety has been grown in Florida and in the Philippine Islands for a considerable number of years, but the crop

thus produced is not exactly identical to that obtained in Sumatra, its home country. There seem to be no other more important factor in causing this condition than the difference of climate existing in Sumatra, Florida, and the Philippines, coupled, of course, with variations in soil.

TABLE 1.—*Climatic conditions of Cuba and U. S. (Connecticut Valley)*

(*a*) MEAN MAXIMUM TEMPERATURE IN FAHRENHEIT

Connecticut valley		Cuba	
April	56.70	October	82.40
May	69.90	November	79.90
June	78.00	December	77.00
July	82.10	January	77.40
August	78.90	February	79.00
September	71.23	March	80.80
(*b*) MEAN MINIMUM TEMPERATURE IN FAHRENHEIT			
April	34.40	October	74.10
May	46.50	November	70.70
June	55.90	December	68.00
July	60.50	January	66.90
August	58.70	February	68.00
September	50.78	March	67.40
(*c*) AVERAGE MEAN MONTHLY RAINFALL IN INCHES			
April	3.33	October	6.57
May	3.78	November	1.94
June	3.79	December	2.27
July	4.70	January	2.75
August	4.86	February	2.06
September	3.85	March	1.21
(*d*) MEAN RELATIVE HUMIDITY IN PERCENTAGE			
April	63.00	October	76.00
May	66.00	November	76.00
June	70.00	December	74.60
July	70.00	January	74.44
August	74.00	February	73.60
September	74.33	March	69.30
(*e*) AVERAGE MONTHLY RAINY DAYS			
April	8	October	15
May	11	November	10
June	9	December	9
July	10	January	8
August	9	February	6
September	8	March	5

TABLE 2.—*Rainfall types in the Philippines compared with Sumatra in millimeters*

	Echague, Isabela	San Fernando, La Union	Davao, Davao	Tacloban, Leyte	Medam, Sumatra
January	66.1	6	118	355.9	196.6
February	38.3	8.2	134.9	220.7	83.8
March	51.6	9.1	161.3	155.7	150.0
April	69	17	162.8	132.9	115.2
May	155.4	191.6	256.6	155.4	213.2
June	99.8	304.7	258.6	199.9	157.0
July	202	621.8	190.1	173.7	126.8
August	208.6	664.4	193	136.8	178.2
September	205.5	451.8	198	150.3	250.6
October	215.9	172.5	255.8	202.2	257.8
November	223.2	42.5	166.5	275.1	302.6
December	157.6	8.6	194.7	350.7	181.0
Annual	1,683.0	2,498.2	2,290.3	2,509.3	2,422.8

Tables 1 and 2 show that Sumatra has almost a uniform precipitation while in the Connecticut Valley, in Cuba, and in the Philippine Islands the weather conditions are quite variable, considering the climatic figures of the last three countries, one might too readily concludee that the differences are not so significant. The fact is, however, that differences exist, and the variability, no matter how slight, is enough to account for the difference in the quality of crop produced in the various districts. Whitney made an irrefutable statement when he said that "the plants are most sensitive to meteorological conditions than are our instruments." Another important factor that must also be considered is the fact that the various field operations and the seasons vary. The Connecticut Valley tobacco season lasts from April to September, while in Cuba, Sumatra, and the Philippine Islands the season lasts from August to June.

TABLE 3.—*Optimum field operations in the principal wrapper-tobacco producing countries*

Countries	Sowing of seed	Transplanting	Harvesting
Connecticut Valley, U. S. A.	April	May–June	August–September.
Sumatra	August–September	October–December	January–June.
Cuba	August–September	October–November	January–April.
Philippine Islands	September–October	November–January	February–May.

It is the consensus of opinion that tobacco is grown to greater advantage in tropical and semi-tropical countries than in tem-

perate regions. One might well ask why the Connecticut Valley, a decidedly temperate region, produces some of the best tobacco in the world. The answer to this inquiry cannot be sought in climatic conditions alone. It is certain, however, that the persistent efforts of research in breeding, acclimatization, selection, and adaptation, coupled with improved and systematic methods of culture and curing, in the United States resulted in the development of tobacco varieties that are among the best in the world. Notwithstanding the prominence of the United States, however, as a tobacco-producing country, the most prominent cigar tobacco-producing regions are Cuba, Sumatra, Brazil, Java, Porto Rico, and the Philippine Islands—practically all tropical countries. Excepting the countries of Sumatra and Java, the tendency of wrapper tobacco growers is to grow wrapper under shelter tents or lath shade. This method of producing wrapper tobacco, while it is seemingly laborious and expensive, is now considered the most practical and economical method of growing a wrapper crop of good quality. Sumatra is favored with ideal climatic and soil conditions which permit her to grow her wrapper tobacco under open culture, a natural process which is not to be found in other tobacco countries. It is claimed that in Sumatra there is an almost even distribution of rainfall throughout the year, and the prevailing practice of using a tobacco ground once in every seven to twelve years insures the production of fine wrapper under open culture.

Inasmuch, however, as certain Philippine regions possess climatic conditions virtually identical with those of Sumatra (see Table 2), the prospects of raising wrapper in this country in open cultures, are quite great.

Soils and fertilizers.—No crop is more responsive to slight changes in soil than tobacco. In the United States as elsewhere, there are only few localities where more than one kind of tobacco is grown. Even in these localities the resultant crop is generally used for the manufacture of only one kind of tobacco product. A good example is the Florida district where filler, binder, and wrapper types are produced, but these products are utilized only for the manufacture of cigars. Different varieties have been bred to meet specific requirements, but when these are transferred to a new environment, they immediately lose some of their characteristics, and consequently, some of their value. It is for this reason that it is not safe to jump at the

conclusion that a standard variety in one place will behave similarly in another locality. The ideal soil for wrapper tobacco ranges from sandy loam to fine sandy loam, which is rich, deep, porous, well drained, and easily worked. Heavy soils, specially clay soils, are not suitable for wrapper-tobacco growing as they are likely to produce coarse and heavy crops. A good supply of organic matter must always be present in wrapper tobacco soils. Organic matter contains all the necessary plant foods in different stages of availability from the freshly turned over dead vegetative matter to the completely decayed and dissolved complex humic food.

To give an idea as to the physical composition of soils suitable for the production of wrapper tobacco, the analyses of representative soils of different wrapper producing countries are given in Table 4.

TABLE 4.—*Mechanical analyses of subsoils of leading wrapper tobacco districts of the world*

Number of samples	District	Moisture in aired sample	Organic matter	Gravel	Coarse sand	Medium sand
		Per cent		*2–1 mm.*	*1–0.5 mm.*	*0.5–0.25 mm.*
29	Florida Peninsula	.62	1.73	.26	2.60	18.94
8	Sumatra	7.48	15.11	1.41	4.39	9.95
6	Cuba (Vuelta Abajo)	.74	3.80	4.06	4.62	8.28
9	Connecticut Valley	.76	2.53	1.03	3.26	9.92

Number of samples	District	Fine sand	Very fine sand	Silt	Fine silt	Clay
29	Florida Peninsula	51.53	18.95	1.33	.59	2.21
8	Sumatra	16.15	17.17	19.11	4.35	5.00
6	Cuba (Vuelta Abajo)	21.67	43.09	6.53	1.82	5.69
9	Connecticut Valley	22.62	45.47	10.41	1.36	2.32

In principle the chemical composition of soils is not important in wrapper production. In the first place, the cigar wrapper is not what is actually tasted by the smoker since in proportion to the entire cigar it is very insignificant. The main objective in the growing of cigar wrapper, is to insure the rapid and uninterrupted growth of the plants and thereby prevent unnecessary thickening of the tissues, since the most desired characteristic of cigar wrapper leaves is their fine texture almost akin to silkiness. And this can only be effected through

an appropriate soil texture. Consequently, the subject of physical condition of the soil, is discussed at length in this paper.

A soil of more than normal fertility is easy to determine by merely observing the excellent growth of the prevailing vegetation. Such soils are obviously suitable for wrapper tobacco, provided, they possess the right physical texture as already described.

In Sumatra and in the Philippine Islands the application of fertilizer does not present so much of a problem. Owing to the abundance of land, the tobacco growers of Sumatra, as has been stated, can afford to use the same tract of land at wide intervals of time. This practice of fallowing the land allows the ground to become virgin once more before it is used for further tobacco growing. In the Philippines, the cigar tobacco districts are located along river banks that are inundated almost every year, and although the same parcel is used annually, the overflow of the rivers always leaves considerable deposits of fine rich soil and decayed vegetation which make the land sufficiently fertile. In the Ilocos provinces, particularly in La Union Province, the small valleys in the mountain regions which are rich in humus, due to the wash deposits from the hills, are the best regions for growing wrapper tobacco. The case is different in Cuba, the United States, and elsewhere. The limited areas suitable for wrapper culture and the large demand for wrapper leaf make it imperative that all available lands be planted every year. The question then arises as to what must be done to these lands in order to keep their productivity at a maximum. In the first place, the application of commercial fertilizer and animal manure must be practiced; secondly, cover cropping and green manuring must be resorted to. In fact, poor ground must be fertilized before the tobacco crop is set in, planted to a quick cover crop after the tobacco is harvested, then plowed under before it reaches maturity. In the United States no crop is so heavily fertilized as tobacco, followed by cover cropping and green manuring. This practice prevails especially in the Connecticut Valley because it is believed there that the application of commercial fertilizer leaves a great deal of residue which will be leached out during the fall rain. The cover crop serves to catch the nitrification products from these residues. The cover crop is later on plowed under as green

manure. Cowpeas, soybeans, vetch, rye, timothy, and other cover crops were found to be among the best green manures for tobacco fields.

The question of fertilizer application is not an easy one to solve. Cases have been known where, by chemical analysis of the soil, the necessary plant foods have been found abundant enough and yet the land has not produced a decent crop. The importance of the desired physical condition of the soil enters into consideration here. Fertilizers only give results when the soil is of the proper texture and contains sufficient moisture to render the plant food available to the plants. To obtain these conditions the soil grains must be thoroughly mixed, hence the value of thorough cultivation and tillage. The question of whether complete fertilizers or simply the elements apparently lacking need be applied, is for the growers to decide. Owing to the high cost of fertilizers, there is a tendency on the part of the growers to use simpler fertilizers. The determination of the deficient plant food then becomes necessary. The deficiency can be determined by classifying the land as to origin and farming adaptation, analyzing it chemically by groups, and testing it by actual field experiment. The purpose of fertilizer application is to produce a rich land, not rich spot, so that the proper method of applying fertilizer is to broadcast and harrow it in. It can however, be applied in the rows and covered during transplanting. The application of coarse manure in the fall or winter, followed either by late fall or early spring plowing, is recommended by the Wisconsin Experiment Station. Commercial fertilizers should be applied in the spring after the land has been plowed and shortly before transplanting. Fertilizers should not be applied unless the land is in good tilth, as otherwise the plants will not be in the best environment to use them. Furthermore, fertilizers, when applied on soil of poor tilth, are readily leached out. As a general guide in the application of commercial fertilizers for tobacco lands the following are recommended.

1. Ammonia, 4 to 5 per cent; phosphoric acid, 2 to 4 per cent; potash, 8 to 9 per cent.

2. Ammonia, 2 to 4 per cent; phosphoric acid, 8 to 10 per cent; potash, 2 to 7 per cent.

TABLE 5.—*Showing the most common sources of the three basic elements, their average composition and value which may be used for tobacco*

Fertilizer	Per cent nitrogen	Per cent phosphoric acid	Per cent potash	Average application per acre	Average value per ton
SUPPLYING NITROGEN					
Nitrate of soda	16	0	0	200 lbs.	$60.00
Sulphate of ammonia	20	0	0	175 lbs.	75.00
Tankage (meat and bone)	5	11	0	400 lbs.	31.00
Dried blood	12	4	0	300 lbs.	60.00
Cottonseed meal	7	2	2	500 lbs.	32.00
Fish	6	8	0	400 lbs.	35.00
SUPPLYING PHOSPHORIC ACID					
Acid phosphate	0	15	0	600 lbs.	16.00
Ground bone	3	24	0	300 lbs.	35.00
Dissolved bone	2	16	0	500 lbs.	25.00
SUPPLYING POTASH					
Sulphate of potash	0	0	50	200 lbs.	55.00
Sulphate of potash and magnesia	0	0	28	400 lbs.	30.00
Wood ash (unleached)	0	0	6	1 ton.	8.00
ANIMAL MANURES					
Barnyard manure	0.5	0.25	0.5	10 tons	2.00
Sheep manure	1.0	0.5	0.5	6 tons	3.00
Chicken manure	1.5	1.0	0.75	4 tons	5.00

Tobacco farmers should avoid the application of fertilizers with appreciable amounts of chlorine, and sulphuric and other free acids, as these elements markedly affect the burning quality of the leaf. Chlorine is contained in common salt, muriate of potash, kainit, and generally in the lower and cheaper forms of potash salts. The use of these fertilizers should, therefore, be avoided. Manures must not be allowed to lie long in the open because nitrogen in the form of ammonia escapes into the air while soluble plant foods such as potash and ammonia are washed out by rain. These materials should, therefore, be kept and seasoned out in farm barns before they are applied in the fields.

Farmers should always refer their fertilizer problems to the nearest experiment station to avoid grave mistakes and possibly useless expenditures. The planter must experiment with fertilizers himself.

III

CHOICE OF VARIETY

There are as many varieties of wrapper tobacco as there are wrapper tobacco regions. A good wrapper variety in one place may not be a good variety in another district and vice versa. Every wrapper-tobacco district should, therefore, strive to develop a standard variety for itself which is ideal for the locality. Among the most important wrapper varieties which are extensively grown in the four wrapper-tobacco districts of the world are:

1. UNITED STATES

Connecticut Valley broadleaf.—The broad-leaf varieties of the United States produce long pointed drooping leaves, averaging in length a little over twice the breadth with a leaf area of about 9 square decimeters. The number of leaves per plant ranges from 16 to 23 and averages from 19 to 20. The average height of plants is about 150 centimeters. Under shade culture the yield per acre is from 1,100 to 1,300 pounds, and under open culture, from 1,600 to 1,900 pounds per acre. This variety sells at slightly more per pound than the Havana. It is grown in the open in the Connecticut Valley for filler and binder, but is also extensively grown under shed tents for wrapper production.

Havana seedleaf.—This variety produces medium-sized leaves, standing nearly erect though drooping slightly at the tip. The average length of the leaf is a little more than twice its breadth. The number of leaves per plant ranges from 16 to 25 with an average of from 19 to 20. The average height of the plants is about the same as the broadleaf varieties. This variety is well known as a wrapper tobacco grown extensively under shelter tents and lath sheds. It is also grown under open culture for filler and binder. The average yield per acre is from 1,400 to 1,700 pounds under open culture, and from 1,000 to 1,100 pounds per acre under shade culture.

Sun-Sumatra.—This is an open field type grown for filler and binder in Florida district. A small quantity of wrapper is also produced from it. This variety was introduced into the United States from Sumatra.

2. SUMATRA

Sumatra.—This variety produces almost round pointed erect leaves a little more than half as broad as they are long, with an average leaf area of about 5 square decimeters. The upper or top leaves are generally narrow and pointed. The average number of leaves per plant ranges from 20 to 32, and the average height of plants is about 210 centimeters. This variety produces an exceedingly high grade of wrapper which is at present considered the standard for wrapper tobacco. The yield per hectare is about 1,500 pounds.

3. CUBA

Cuban Havana.—This variety is the same as the United States Havana and the Texas Cuban varieties. It has rounded almost erect leaves. The number of leaves per plant ranges from 16 to 25. The leaves are bigger than those of Sumatra. Havana is a very popular variety in Cuba, grown both for filler under open culture and for wrapper under shade culture. Under open culture, Cuban Havana produces as high as 2,000 pounds per acre and as high as 1,400 pounds per acre under shade culture.

4. PHILIPPINE ISLANDS

Simmaba.—A dual purpose variety originally found in La Union Province, similar to the standard "Marogui" variety of the Cagayan Valley. It is grown mostly in the mountain regions. In shape the leaves resemble the United States broadleaf varieties, but are even larger. Plants produce from 28 to 36 leaves, with standard measurements of 104 centimeters in length and 68 centimeters in width. The height of the plants ranges from 200 to 245 centimeters. Grown in the open, it produces as much as 1,500 kilos, and under shade culture 1,000 kilos per hectare. It can well resist the wilt disease. So far it is the best native variety for shade culture under droughty conditions as prevailing in La Union Province. The leaves can be easily cured to a light color. This variety has been improved by selection by the Bureau of Plant Industry.

Vizcaya.—This variety produces as big as but narrower leaves than the Simmaba. Its leaves, however, possess a good curing quality, turning light quite readily. The leaf length is generally more than double the width, and the plant grows exceedingly tall, reaching a height of from 220 to 250 centimeters. The average number of leaves varies from 28 to 42 leaves, including

the tops. This variety was originally found in Cagayan Valley, where it is now grown quite extensively after six years of rigid selection at the Ilagan Tobacco Experiment Station. It is preferable for shade culture under somewhat moist or less droughty conditions as prevailing in southern Laguna Province. It is also a dual purpose variety.

Philippine Baker's Sumatra.—The plants have the same development as the genuine Sumatra with an average height of 210 centimeters. The average number of leaves is 30, with average measurements of 42 centimeters in length and 27 centimeters in width. When grown in the open it gives an average of 1,008 kilos per hectare, 324 kilos of which are marketable wrapper. Under shade culture, it produces 658 kilos per hectare, 400 kilos of which are marketable wrapper. This is a small to medium-leaved variety. When grown in the open and planted quite late, it cures readily to yellow. The variety is of Sumatra origin, introduced into the Philippines through the efforts of the late Dean Charles Fuller Baker of the College of Agriculture, University of the Philippines.

Ilagan Sumatra.—The Philippine Baker Sumatra is a perfectly satisfactory cigar wrapper variety, but, principally because of the prejudice of the Filipino tobacco grower against small and medium leaved varieties, intensive pure line selection was started during the 1924–1925 season at the Ilagan Tobacco Station, to develop a strain which if possible will produce bigger and rounder wrapper leaves. At this time the mean breadth index of the Philippine Baker Sumatra was 52.78 per cent. During the 1928–1929 season a strain with virtually 70 per cent breadth index was developed. This strain, differing from the original variety in at least two important characters and being true to type, naturally is called a distinct standard variety of the cigar wrapper type. The variety has been called Ilagan Sumatra to commemorate the town of its origin. This variety differs principally from the Philippine Baker Sumatra by its wider and larger leaves. The Ilagan Sumatra has ovate-orbicular leaves (Plate 29) while the Philippine Baker Sumatra has ovate leaves.

IV. SEED BED AND FIELD OPERATIONS

Preparation of seedbeds.—The successful production of wrapper tobacco depends in a large measure upon the farmer's ability to rear vigorous, uniform, and healthy seedlings. Any land that

is good for growing tobacco may be utilized for seed bed purposes. It is the general practice, however, to use higher ground for seed beds to avoid the possible danger of floods and stagnant water. Sloping virgin lands, if available, are the best locations for seed beds as the difficulties of laying deep drainage canals and the application of fertilizers are thereby avoided. In the tropics, the beds are prepared one meter by ten meters. This is a convenient size for the many operations involved—constructing, weeding, placing covers, watering, etc. The earth is raised about a foot above the general level in bed form and the sides of the beds are supported by bamboo which may be substituted by wood. A patch about a half a meter wide, which serves also as drainage, separates the plots. Each bed is thoroughly worked to a depth of more than one foot. All roots, stumps, and other waste materials are raked out and the soil is thoroughly pulverized. This done, the beds are sterilized. There are various methods of seed bed sterilization, namely:

(1) *Open-fire.*—In the tropics, where dead vegetation is abundant, the seed plots are covered with dry grasses, twigs, and bushes and are then burned. The heat is forced through the beds, killing suckers, roots, and seeds of weeds and fungus and bacterial organisms.

(2) *Roasting.*—Heating or roasting the soil in a suitable pan is a modification of the open-fire method. The soil of the beds is shoveled into pans and heated to a certain degree in order to kill all fungi and bacterial organisms. Then it is returned to the beds.

(3) *Hot water treatment.*—The beds are treated with boiling water to kill all weed seeds, roots, suckers, fungi, and bacterial organisms.

(4) *Formaldehyde treatment.*—A solution of formaldehyde (one part formalin to 100 parts water) is sprinkled on the beds at a ratio of one gallon per square foot. The beds are then covered with burlap or sash to hold in the fumes. After a week they are ready for sowing. The common objection to this method is the costliness of the formalin.

(5) *Steam sterilization.*—Steam current from a boiler is passed through the soil several times. This method was devised by the U. S. Department of Agriculture, Bureau of Plant Industry and is now being extensively used in the Connecticut Valley. The outfit necessary for the operation consists of a boiler, some lengths of good pressure hose, and two or more pans made of galvanized iron or wood.

The use of any one of these methods depends upon its suitability to the place. In the Philippines, for instance, tobacco farmers do not sterilize their seed beds but simply select virgin places for them.

The importance of the use of fertilizers on old land for seed beds is best summed up by Olson in Bulletin 130 of the Pensylvannia Agricultural Experiment Station as follows:

> Tobacco plants are forced to spread their roots widely when growing in an insufficiently fertilized bed. This causes slow growth above the ground, and when the plants are pulled the straggling spreading roots are damaged, a condition which later interferes with the growth in the field. It is, therefore, advisable to fertilize the beds well for the reason that the plants will not only grow faster but the roots will not spread out in search of food; they obtain it in a small area, and consequently grow in a close, compact branch which makes it possible to pull the plants with small loss and less injury to the rootlets.

The application of fertilizer, however, requires discretion. While mineral fertilizers can and should be applied after sterilization, compost and animal manure should be applied before sterilization as these fertilizer materials may likely contain destructive organisms that will damage the seedlings. In the U. S. Department of Agriculture Farmer's Bulletin 571, Dr. Garner suggests the following method of fertilizing tobacco seedbeds:

> In the fall 40 pounds of lime and 200 pounds of stable manure to 100 square feet of seedbed are plowed under. In the spring about two weeks before sowing the seeds, additional fertilizer should be applied per 100 square feet of bed area consisting of 20 pounds of cotton seed meal or castor pomace, 1 pound of acid phosphate, and one half pound of carbonate or sulphate of potash. These materials are thoroughly spaded into the soil to a depth of 4 to 5 inches and the surface of the beds brought to a fine tilth.

In the Philippines, in La Union Province, powdered and well decomposed chicken manure is used for dressing tobacco seedbeds with excellent success. The manure is spread over after the seed is sowed.

Once the beds are formed, sterilized, and fertilized, a suitable shelter is constructed over every bed to protect the beds from heavy rain and strong sunlight. The shelter is raised about a meter in front and seventy centimeters at the rear to facilitate moving about during watering, weeding, and worming. Sheds on seed beds are important to reduce evaporation, so that more moisture remains in the soil, hastening germination, and at the same time to protect the seedlings from heavy rain. In the Tropics palm and grass leaves are used for seed bed covers. In

the United States the seed beds are similarly constructed although the width is even more than 6 feet and the area not less than 180 square feet. In the northern districts like Connecticut, substantial frames are built over seed beds to hold the cloth or glass covers. In some cases, steam pipes are laid in the beds for heating the soil in case of emergency.

Sowing of seeds.—Experience is the safest guide with reference to the right time for sowing. In the temperate countries the best time for sowing the beds is from the middle of March to the middle of April. This time is computed principally on the ground that it takes from six to eight weeks to produce transplanting seedlings in cold beds and from four to six weeks in hot beds. If cloth cover is used instead of glass, at least two more weeks must pass before the seedlings are ready for transplanting. If sowing were done earlier, resulting in earlier planting, the dangers of late frost might be encountered. The following dates from the records of the U. S. Weather Bureau show the average actual time of the last killing frost in the spring and the earliest killing frost in the fall in the wrapper tobacco districts of the United States.

TABLE 6.—*Showing the average time of the last killing frost in the spring and the earliest killing frost in the fall in the United States.*

State and locality	Spring		Fall
	Average	Last	Earliest
Connecticut, New Haven	May 30	May 30	September 15.
Massachusetts, Boston	---------	May 17	September 30.
Florida, Pensacola	May 7	Apr. 6	November 12.

In the Tropics, the chief problem of the growers lies in the rain which may fall too late, just like the frost. Late rain means late transplanting. The only effective way by which planters can overcome this uncertainty of the weather is the sowing of seed beds three times more than necessary at intervals of 15 to 20 days, beginning the middle of August. Seeds must be sown sparsely to avoid thick growth or overcrowding of seedlings as this results in the production of weak seedlings. Thick sowing also predisposes to damping-off disease which is very common in seed beds.

In Sumatra one gram of seed mixed with sifted carrier, such as sterilized dust or ash, is sown into every square meter of seed bed, or one teaspoonful of seed for every 100 square feet of seedbed. A bed of 10 square meters usually yields not less than 2,000 good seedlings. This method of sowing in Sumatra is similar to that employed in the Philippines. In the United States, Dr. Garner of the Bureau of Plant Industry suggests sowing at the rate of an even teaspoonful of seed to every 100 square feet of bed area and to secure an even distribution, the seed should be mixed evenly with wood ash. The beds are packed down after sowing either with a roller or a plank and then covered with cloth, glass, or palm leaves. The practice of sprouting or forcing the seeds to germinate before sowing in order to gain an earlier start is not a good one. It is more advantageous for the seed to germinate at the temperature and on the place where it will have to spend its early growth than to hasten germination in an entirely different environment and to transfer it later to the seed plots.

Care of seedlings.—After the seeds are sown, they should be watered to keep the soil moist. Too much watering is to be avoided, however, as it causes the soil to harden upon drying. As soon as the seeds have germinated, the beds should be sprinkled regularly every day, but sparingly. When the weather is too windy, watering the beds twice a day becomes very necessary, as evaporation is rapid during windy days and the beds dry up more quickly. The beds should be uncovered occasionally to expose the seedlings to the morning sun in order to harden them. This, too, is necessary to avoid fungus diseases. In the Philippines, it is the practice to remove permanently the sheds of the seed plots 20 to 30 days after sowing, allowing the seedlings to grow in the open as soon as they are strong and big enough to resist strong rain and sunshine. In this way, the seedlings become accustomed to growing under natural field conditions, and, when transplanted in the field, recover very quickly. The beds should be weeded regularly as soon as the seedlings are big enough not to be disturbed or pulled out with the weeds. If worms appear in the seed bed in sufficient abundance to be dangerous, the seedlings should be dusted with calcium arsenate mixed with wood ash to the proportion of one part calcium arsenate to 20 parts wood ash or other suitable carrier. If a

solution is used instead of the powder, the calcium arsenate solution shouuld be only of one to two per cent concentration. In either case, the seedlings should be dusted or sprayed only sparingly as overapplication of the arsenical may burn the leaves if not altogether kill the plants, especially if the concentration is quite strong. The Flit guns is a handy and cheap sprayer if the use of solution is resorted to. If a hand dusting machine is not available, an ordinary cheese cloth bag will be a good substitute for dusting purposes. The bag is filled with the powder mixture and shaken over the seedlings. This method of dusting was found very practical and quite convenient in the Cagayan Valley.

Preparation of the field.—The field should be plowed at least twice to a depth of about a foot and then thoroughly harrowed to enable the roots of the seedlings to extend well down. Thorough stirring of the soil also conserves the soil moisture, and, at the same time, distributes the fertilizer uniformly. With a well-distributed food supply and sufficient moisture in the soil the growth of the plants will be rapid and normal—conditions which are essential in securing leaves of the finest texture. Slow growth due to improper preparation of the field results in the slow development of the plants, at the same time risking the exposure of the plants to early drought and, what is worse, to the attack of insect pests for a much longer period of time. It may be of interest to consider in this connection the fact that in the tropics every phase of the work in the field from the clearing of the ground to the curing of the crop is still done by man and animal power, while in the United States most field operations are performed by machinery.

Transplanting.—Seedlings should be ready for transplanting from 45 to 60 days after sowing, or when they are about 5 or 6 inches high. Seedlings fit for transplanting must be sound, healthy, vigorous, and uniform in size. Great care must be exercised in pulling the seedlings from the beds, as the slightest injury to the stems and roots retard the growth of the plants. If there has been no recent rain to soften the ground sufficiently to make it easy to pull the seedlings, the necessary amount of water must be sprinkled on it before attempting to pull them out. The best time to transplant is after three o'clock in the afternoon. On cloudy days, however, transplanting can go on

throughout the day. If the weather is too hot during transplanting, it is necessary that the newly set plants be protected from the sun by covering them for at least three days with banana petioles or other suitable materials. Once transplanting has begun, it should go on uninterruptedly until the whole field is planted. This is very desirable for uniformity of the stand. When there is uniform stand, priming is facilitated and a very uniform crop is obtained. The leaves are harvested all at the same time and at almost the same maturity. The period of transplanting wrapper tobacco in the different wrapper tobacco districts is given in Table 3, together with other field operations. Under open culture, the plants should be set nearer in order to protect the majority of the leaves, especially the lower ones, from a good deal of light. The leaves will intershade intimately and under such conditions will become fine, thin, and elastic. The big varieties, such as Broadleaf, Simmaba, Viscaya, and Havana seedleaf, when grown under open culture, should be planted from 80 to 90 centimeters between the rows and from 60 to 70 centimeters between the plants in the row. The Sumatra varieties, because of their small size, can be planted at 80 centimeters between the rows and 40 to 50 centimeters between the plants in the row, either open-grown or shade-grown. Under shade culture opinions on distances of planting vary. Some planters prefer to grow their tobacco at closer distances in order to accommodate more plants per unit area of shaded ground, while others plant their tobacco at greater distances in order to obtain big but fine, thin, and elastic leaves. What distances of planting should be followed depends upon the variety to be planted and the fertility of the soil. In rich lands, spacing can be closer even for the big varieties under shade culture. The plants will develop big leaves just the same, but under open culture it is necessary that the leaves of the plants in the rows interlap to produce a fine-textured wrapper crop, hence the necessity of planting closer between the plants. In the Philippines, the big varieties under shade culture are spaced 80 by 70 centimeters apart, the Sumatra varieties at 80 by 50 centimeters, in open as well as shade culture. In Sumatra, where shading is never resorted to because of the favorable natural conditions, the "alternate close and distant row"

method of planting is practiced. That is, the plants are set in a triangular way (quincunx effect) as in the following diagram:

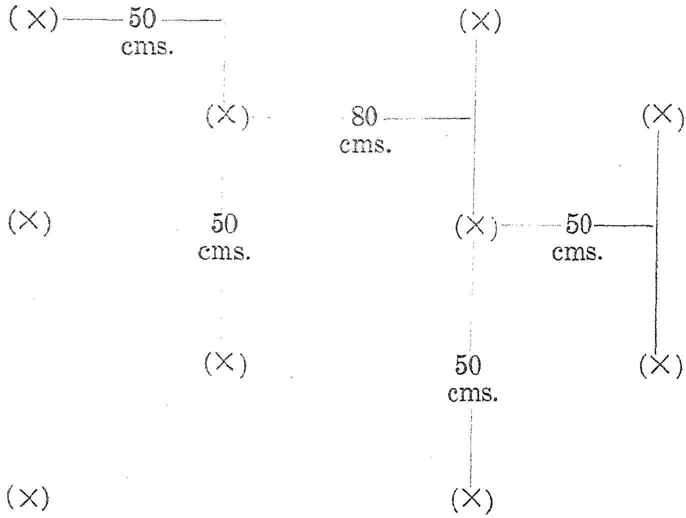

DIAGRAM 1.—Showing Sumatra method of setting cut plants.

Setting is done either by hand or by machinery. Hand setting is, of course, very simple. The rows and the points where the plants are to be set are marked by sticks or pegs. With the dibble, a hole 4 to 6 inches deep is prepared into which the plant is placed perpendicularly up to its neck. The soil is then packed around the plant to give the root a firm hold and at the same time to brace the stem. The newly set plant is then hand-watered and the wet soil covered with dry soil to prevent rapid evaporation and baking. This covering of the wet soil around the plant with dry soil is very important because, if the soil is allowed to bake, it shrinks and subsequently cracks, so that a considerable amount of moisture escapes and at the same time the root system of the plants are strained. The tobacco transplanting machine is a labor-saving device and is now extensively used in the United States. It has its advantages in that the setting of the plants in proper distances, transplanting, packing the soil around the plants, and watering are all done automatically. An ordinary transplanting machine is drawn by two horses and carries a driver and two planters who manipulate all the transplanting operations, each man setting alternate rows. A V-shaped plow makes an opening into which the plant is set and is held in place until the soil around it is

packed by means of a pair of paddle-shaped blades which follow the plow. By means of a special gearing on the wheels, definite quantities of water are released at uniform distances. With the transplanting machine the human labor is dispensed with, even in planting large areas. Replanting should follow after a week, as it never happens that all plants set initially survive. Bigger seedlings should be used in replanting, and there should be enough of these seedlings on hand for the purpose.

Cultivation.—In two or three weeks after transplanting the plants should have fully recovered and cultivation can begin. Cultivation is the process of stirring the ground in order to keep the soil from hardening or becoming compact. It enables the roots to extend freely and also eradicates weeds and conserves soil moisture. Cultivation is done either by plowing the space between the rows or by hoeing, to form ridges on the rows of plants. The tooth-cultivator and the tobacco hoer implements are both great labor-saving devices. Unless weather conditions interfere, the fields should be cultivated every ten days. Three cultivations done thoroughly are sufficient, as by that time the plants will be too big for further cultivation, if growth has been rapid. In Sumatra, where the "alternate close and distant row" method of transplanting is practiced, cultivation is done by banking. By banking is meant the construction of deep drainage canals every two or more rows of tobacco, the soil dug therefrom being deposited on plant beds formed therein. Eventually the plantation is divided into beds gradually elevated, as the excavation of the canals continues. In some instances the canals are almost a meter deep. The Sumatra method of growing and cultivating tobacco is very laborious and expensive and only the abundance of cheap coolie labor permits this practice in Sumatra. What advantage this method has over the system in vogue elsewhere, is hard to determine; the construction of deep canals may be indispensable in Sumatra because of the even distribution of rainfall throughout the year. The primary purpose of these canals is to drive out or to get rid of the excessive water that may likely flood the plantation. This Sumatra method of growing tobacco has been tried in the Philippines, but results obtained thus far are not as yet very satisfactory.

Control of tobacco worms.—As the primary object in growing wrapper tobacco is to produce sound leaves, one can readily see

the importance of vigilant control of all destructive pests of the crop while it is growing in the field. The false budworm, the cutworms and the hornworms are universally admitted to be the most destructive insect enemies of the tobacco plant from the seed bed until the last leaf in the field is harvested. It requires an army of worm pickers to keep the worms fully under control. This is accomplished either by hand picking, by spraying, or dusting the buds of the plants with arsenicals. Of course, the production of wrapper tobacco under tents minimizes the damage of these worms on the crop but does not entirely check their destructiveness. Calcium and lead arsenate are among the best insecticides for the control of tobacco worms. These arsenicals, when used in solution, should be in the correct concentration to avoid the burning of the leaves, otherwise their application would be more destructive than beneficial. In Sumatra as in the Philippines, 300 grams of the arsenical powder was found to be the best basis for dusting. That is, every 100 grams of sifter or carrier, like wood ash or sterilized road dust, should be mixed with 5 grams of the arsenical powder, or in the proportion of one part powder to 20 parts carrier.

Topping and suckering.—Topping and suckering are two distinct operations having a common end. Topping is the removal of the flower head by pinching, while suckering simply means the removal of all suckers or buds at the axils or junctions of the leaves. The work on suckering and topping requires the exercise of some discretion. At or about the time when the plants are beginning to flower, practically all the food material which are being taken in by the plants are utilized for the nourishment of the flower head and the top leaves. Opinions regarding topping vary. There are growers who believe that topping is a necessary operation, while there are others who insist that topping can be dispensed with entirely in the production of wrapper tobacco. The reason is obvious. Topping is believed to thicken the leaves. On the other hand, untopped plants are supposed to produce a crop of bitter taste. The writers' opinion is that topping is discretionary. When a plant apparently is not in a vigorous condition, it should be topped so that the plant food, instead of being consumed by the flower head and top leaves, can be utilized for the development of the standard leaves. When the plants are vigorous enough, topping ought not be undertaken since this operation favors the development of coarse, thick leaves. If resorted to, however,

it should only be performed when the standard leaves are already harvested. The plants for the production of seed should, of course be selected first, then the rest of the plants can be topped. Suckers do not appear abundantly until after topping, so that suckering is a subsequent operation. Suckers deprive the plant of a great deal of food and therefore, should be removed as soon as they appear. After the standard leaves are harvested, two suckers from the base can be allowed to develop for the production of filler or binder. This crop is usually termed "retoño." Sometimes suckers are allowed to grow when the main plant has been damaged in order to replace the loss.

Harvesting.—In harvesting wrapper tobacco, the leaves should be primed, that is, picked singly from the stalk as soon as they show the right maturity. It is hard to make a definite rule as to when exactly they are ready for picking. Of course, it is fairly easy to distinguish a mature leaf from a green one, but to harvest a leaf at the proper degree of maturity in order to obtain a good crop and do so throughout a whole harvesting period is a delicate operation. Only by experience does one become a successful operator. An almost uniform color of cured crop is easily obtained if the uniform maturity of leaves is maintained upon priming. If a leaf is picked green, it has, when cured, an undesirable dark color and a bitter flavor; when picked overmature, texture and flavor are also affected. Among visible indications of ripening are the slight yellowing of the edges of the leaves, especially at the tip, and the changing of the entire color of the leaf from deeper to lighter green. Priming on every plant should be done at least once a week. By the adoption of this schedule, it will take from 5 to 8 primings to harvest an ordinary wrapper crop. In the course of priming, the leaves are piled along the rows as the load becomes too heavy to carry along. These piles are in turn gathered into convenient baskets and taken to the curing barn. Great care must be taken in handling the leaves during priming so as to avoid mutilation, breakage, or scratching, since the slightest injury to the leaves is a permanent damage to the finished product. Opinions among tobacco men as to the time of day for the harvesting of wrapper tobacco differ. Some growers advocate the harvesting of the crop only during early morning, when the plants are not yet actively doing photosynthetic work; it is supposed that the leaves are then in finest condition. On the other hand, other

growers contend that harvesting wrapper tobacco when the leaves are still wet not only diminishes the gum but also causes them to sweat readily, producing an undesirable black color which kills the finish of the leaves and easily brings about decay. For this reason, priming should be done not earlier than 9 o'clock in the morning. The experience of most growers, however, is that in most cases the time of priming need not be limited but can be carried on continuously from morning till afternoon every day. This is the case with big plantations where it takes a week or more to complete the cycle of one priming in a big field. Harvesting goes on irrespective of whether the leaves are wet or dry, or whether it is morning, noon, or afternoon, since to delay the harvesting is far more detrimental to the crop as a whole. The most important thing to remember is that the leaves must be harvested at the proper degree of maturity or ripeness. One precaution that should not be overlooked is to make certain that all leaves are poled before the day ends. Harvests should not be allowed to lay in big piles overnight, because when allowed to do so for a considerable length of time the pile sweats and develops heat that destroys the quality of the finished product. Other than this, there seems to be no valid reason for exactly limiting the hours of harvesting. Neither is wilting a necessary process preparatory to poling or stringing. On the contrary, fresh turgid leaves are easier to handle in poling than wilted ones.

V. THE GROWING OF WRAPPER LEAF TOBACCO UNDER SHADE

The practice of growing wrapper tobacco under shade is quite a recent innovation. In Florida an attempt was made to introduce the raising of tobacco by shading in 1896. The initiator of this idea was A. D. Shaw of Quincy, Florida. The first effort proved unsuccessful. Lath shade supported by posts was first tried. Later, in 1900, the trial was made in the Connecticut Valley on the farm of John Dubon of Poquonock County. This experiment was under the auspices of the United States Department of Agriculture. A shelter tent of cheese cloth was used instead of lath shade. In 1902, the officials of the Connecticut Agricultural Experiment Station of New Haven announced that, "no further evidence is required to demonstrate that tobacco of the Sumatra type can be grown in the State

of Connecticut which is equal in all respects to the average imported Sumatra." It will be remembered that the variety first tested, both in Florida and in Connecticut, was the Sumatra variety, as it was the aim of the experiment to produce Sumatra wrapper from the Sumatra seed that would be just as good as the imported Sumatra. The Sumatra variety, howver, did not make good. It was found later that it does not produce a good crop in the United States. The shading experiment nevertheless succeeded, after many reverses, by the use of the acclimatized Cuban seeds. At the present time the Connecticut Valley annually produces from 70 to 80 per cent of all the shade-grown wrapper tobacco of the United Sttes, mostly of the Broadleaf and the Havana seedleaf varieties. The use of artificial shade involves considerable expense, but the high prices offered for shade-grown crops have justified the practice. To-day the use of shelter tents in growing wrapper tobacco is not confined to the United States, but is also resorted to in Cuba, Puerto Rico, and in the Philippine Islands. The principal purpose of shading is to produce a 60 per cent shade for the protection of the plants from direct exposure to strong sunlight, to conserve moisture, and to lessen damage by insects. All other phases of the work are governed by the same principles that hold for the open-grown wrapper.

The following description of a shelter tent is from Bulletin No. 138 of the United States Department of Agriculture, Bureau of Plant Industry:

> Too much stress can not be laid upon making the tent frame strong in every way, so that there will be as little given to it as possible. The outside posts should be well guyed, so that the wires will remain taut when stretched. Much trouble is often caused by the main wires to which the cloth is sewed, becoming so loose that the pull of the cloth can move them up and down. This gives the cloth a chance to jerk and break the cord which holds it to the wire, causing a rip, which is difficult to repair. The most economical distance to set the post is 24 feet apart each way. To set them further apart is not safe because the strain upon the cloth in a high wind involves the danger of loosening the covering at a critical time.
>
> In preparing to erect a tent the first essential is to lay off the land and place a small stake where its post is to be located. To this, start at one corner and lay off a square and set a side and an end row of stakes across the field at right angles to each other, sighting them in line and measuring the distance to put them apart in the row. When

this is done the rest of the field can best be laid out by the use of a triangle the sides of which are the desired length. Put one leg of the triangle against the row of stakes and the other leg against the side row and place the new stake in the corner of the triangle. Repeat this until all of the places for posts are marked.

The digging of the holes is a simple operation and consists of removing a small portion of the top soil with a shovel and then deepening the hole to the desired depth, which should not be less than three feet, by the use of a common post-hole digger. The post should be cut at least 11½ feet long and set three feet in the ground, this marking the tent 8½ feet high. When the variety used is tall-growing the tent can be made a little higher. In aligning the posts the tops should be sighted and leveled by lowering or raising a post where necessary, the rows being kept straight.

To guy a post, a timber not less than four feet long and six inches in diameter, to which is attached a No. 9 wire, should be sunk in the soil to a depth of three feet, not less than six feet from the base of the post, and the other end of the wire made fast to the post. This done the next thing is to stretch the wire. First, run the main No. 6 wire to which the cloth is to be sewed. Make one end fast to the top of an outside post and stretch the wire tight by the use of a block and pulley or some other powerful means of pulling and fasten it to the top of the post at the other end of the field. This wire should be fastened firmly to the top of each post in the row.

After all the main No. 6 wires have been put on and fastened, cross wires should be run on the top of these. At the top of the cross rows of posts use No. 9 wire, and at intervals of four feet between the posts stretch a No. 12 wire, fastening it to the outside wires on the sides. At the crossing of the two wires, they should be fastened by twisting about them a short piece of small wire; No. 16 wire is a convenient size for this purpose. At the bottom of the outside posts run a No. 9 wire for the purpose of fastening the bottom of the cloth.

The cloth used for the tents comes from the mills sewed into strips 84 feet wide and usually 60 yards long. This cloth is run on the wires by threading it under one cross wire and over the next one, and where the ends of the strips meet they are sewed together. The edge of the cloth is now wound around the wire and made fast by sewing with strong twine. The operation is repeated until the whole field is covered and the tent complete.

In the Philippines, bamboo which grows everywhere is used as frame for shelter tents and the leaves of coconut and nipa palms are cheap materials for shading. As a rule the shade frame is erected as early as is practicable, at times put up even before transplanting. The shading materials are placed when the plants are about half a meter high. Shading of the field when the plants are still very small should be avoided since it tends to make them tender, weak, and slender. But once the shading is begun, it should go on without interruption or delay; the sooner the shading is completed the better, as a

more uniform crop will be obtained. Great care must be observed in equalizing the even thickness of the shade, as uneven shading results in the production of a crop of various degrees of fineness. The posts of the frame must not be less than 2.5 meters high and must be set lengthwise after every 4 rows of plants and crosswise after every 6 to 8 rows. They must be buried deep enough (3 feet) to resist strong winds. In places where palm leaves are not available the use of talahib (*Sacharum spontaneum*) and cogon grasses (*Imperata cylindrica*) is resorted to.

Shading has various effects upon the crop. Partial results obtained in the Philippines show that shading tends to increase area, diminish weight, improve burning quality, accelerate growth and maturity, and, above all, render the leaves thin and of a light color. In the United States cheese cloth containing 12 threads to the inch produces higher and better crops than similar material with more or less than 12 threads to the inch. In other words, a shade made of any of the above described materials that approximately allows only 40 per cent sunlight to pass through is the most appropriate shelter tent for obtaining the best results. An experiment is now under way in the Philippines wherein the use of abacá cloth for shading tobacco plantations is being studied. If the experiment proves successful, it will mean an added economy on the part of the growers. The material is cheap, considering the present low price of abacá, and it could be used for a period of three or more seasons.

The shading of wrapper-tobacco fields has many other advantages. It greatly minimizes, if not altogether controls, the fussarium wilt disease of tobacco. This has been amply demonstrated by the test conducted for the last three years in the wilt-ridden districts of La Union Province in the Philippines. The shaded soil, retain more moisture, and the cooler atmosphere of the shaded plantations seem to be the favorable factors. Shading also affords more food for the plants, so that stunting is eliminated. Because the soil is not packed by alternate drying and wetting, it remains in better physical condition. The lower temperature in the tent approximately equals the established optimum growing temperature. Furthermore, as Stewart claims, "there is less variation in the temperature in the tent which is generally recognized as a factor of great importance."

TABLE 7.—*Showing Stewart's observation on the effect of a tent on soil moisture, temperature, relative humidity, and wind velocity*

Observations	Average soil moisture	Average temperature	Average relative humidity	Velocity of wind
	Per cent	*Fahrenheit*	*Per cent*	*Miles per hour*
Inside of tent	14.7	72.8	79.0	1.00
Outside of tent	11.6	71.4	71.7	10.00
Difference	1.4	1.4	7.3	9.00

The advantage derived from greatly increased relative humidity of the atmosphere by shading is well defined by Strassburger, Noll, Schenck, and Schimper:

It acts as a stimulus, and also, by diminishing transpiration, increases turgidity.

The velocity of the wind is very much reduced, which decreases evaporation and protects the plants from being whipped, brushed, or blown down.

Dr. H. Hasselbring, while conducting tobacco experiments in Cuba, claimed to have found that plants grown in the open absorbed and transpired the greater quantity of water, contained the smaller percentage and the smaller absolute quantity of ash.

Some of the conclusions reached by Lutzer show that abundant sunlight, high temperature, liberal nitrogen manuring, and sparing use of water in the soil, produce a large percentage of nicotine; also, that the direct sunlight favors a high potassium but a low chlorine content.

In shade culture the ideal large-sized varieties for wrapper are preferable to the small-sized varieties to compensate the high cost of production by obtaining a higher yield per unit area. In the United States, the Broadleaf is now the dominant variety for shade culture, although in the beginning the Sumatra varieties were tried. The growing of Sumatra types under shade was finally given up, and in their place were substituted the acclimatized Cuban varieties. The same thing is happening in the Philippine Islands.

VI. CURING SHED, CURING OPERATIONS, FERMENTATION, CLASSIFICATION, AND BALING

The curing shed.—While substantial farm barns which are spacious and well ventilated may be utilized for curing tobacco,

it is always better and more profitable in the long run to have a standard curing shed exclusively for tobacco. This is particularly so in the case of wrapper tobacco, wherein a delicate and costly product is desired. As a general requirement, wrap-

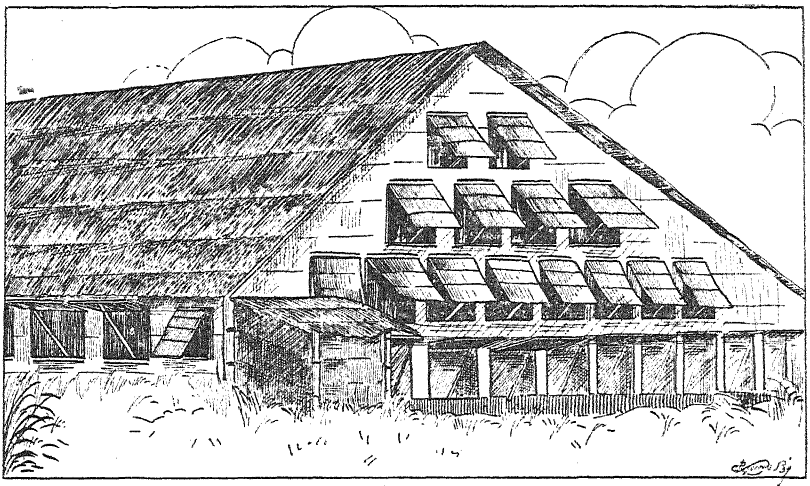

FIG. 1. A typical curing shed for wrapper tobacco in Sumatra.

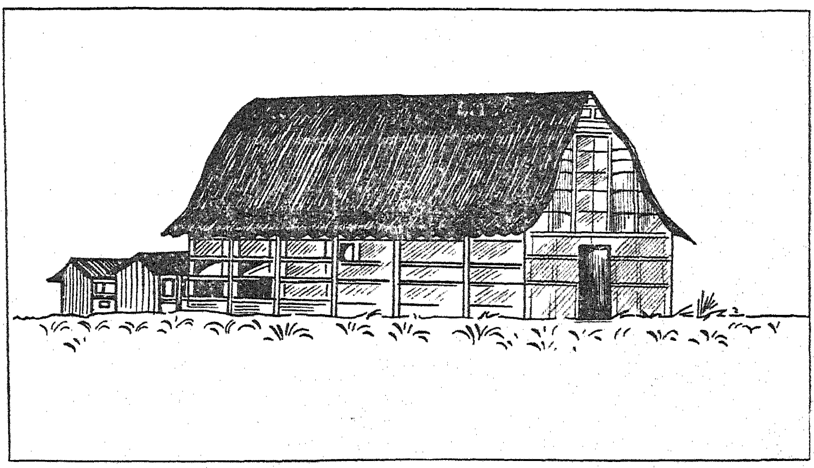

FIG. 2. A typical curing shed for wrapper tobacco in Cuba.

per-tobacco curing sheds should be spacious and the inflow and outflow of air well controlled by an adequate ventilation system. Successful growers in the United States have adopted many different systems of ventilation, the most common of which are the following: (1) Top ventilation secured by means of

slatted ventilation set in the gable ends of the shed or in the roof along the ridge pole, or by means of valved, cylindrical metal ventilations set in the roof peak; (2) sill ventilation constructed either by inserting loose boards vertically at intervals of a few feet along the side walls of the barn or by hanging horizontal boards above and fastening them to a common lifting rod. The boards are fixed to the sides of the sheds at points near the lower end of each tier; and (3) bottom ventilation sometimes is resorted to by making the floor beam project on each side beyond the foundation walls. The wall plates rest upon the ends of these beams, forming trap doors when the floor between these two walls is raised. Many of the most modern curing sheds now in use in the United States are provided with ventilation systems combining two or all of the above described types.

For an idea of the materials necessary for the construction of a permanent curing shed under United States conditions the following data of estimates of materials for the construction of a permanent curing shed capable of curing a crop from a 100-acre farm is hereby given. This data is obtained from the No. 62 Report of the United States Department of Agriculture:

1. Sills, 22 pieces (6″ x 6″ x 20′ or 1,320 ft.)
2. Studding, 24 inches center (160 pieces) 2″ x 4″ x 18′ or 1,900 ft.
3. Plates, 14 pieces (2″ x 6″ x 20′) or 280 ft.
4. Rafters (26 inches centers) 88 pieces, 3″ x 6″ x 34′ or 188 ft.
5. String back for rafters, 6 pieces, 3″ x 6″ x 32′ or 288 ft.
6. String back for supports, 14 pieces, 3″ x 6″ x 8′ or 168 ft.
7. Uprights for tiers, 10 pieces, 4″ x 4″ x 21′ or 280 ft.
8. Uprights for tiers, 10 pieces, 4″ x 4″ x 29′ or 230 ft.
9. Upright for tiers, 10 pieces, 4″ x 4″ x 27′ or 360 ft.
10. Uprights for tiers, 10 pieces, 4″ x 4″ x 30′ or 400 ft.
11. Tier poles, 240 pieces, 2″ x 4″ x 16′ or 2,560 ft.
12. Ribbons, 56 pieces, 1″ x 4″ x 20′ or 274 ft.
13. Cross braces, 14 pieces, 1″ x 6″ x 25′ or 165 ft.
14. Ventilators, 16 pieces, 1″ x 12″ x 12′ or 192 ft.
15. Ventilators, 32 pieces, 1″ x 12″ x 10′ or 320 ft.
16. Sheating for roof, 2,750 ft. 1″ x 3″ or 2,750 ft.
17. Weather broading, 4,500 ft. 1″ x 6″ or 4,500 ft.
18. Door and shutters, 1,000 ft. 6 and T ceiling or 1,000 ft.
19. Pillars, 2,000 bricks.
20. Pillars, 2 barrels, stone lime.
21. Singles, 6 inch to the weather, 30,000 (4″ x 18″) cypress.

22. Ventilators, 50 pairs, 8 inch strap hinges.
23. Shutters, 22 pairs, 8 inch strap hinges.
24. Door, 3 pairs, 12 inch strap hinges.
25. Ventilator levers, 24 angles brackets.
26. Shutter props. 11 pairs, 6 inch T hinges.
27. Intermediate tiers for primed tobacco.

    (*a*) 5,200 ft. barn wire.
    (*b*) 20 pounds staples.
    (*c*) 2 kilos 4 penny cut nails.
    (*d*) 3 kilos 10 penny cut nails.
    (*e*) 2 kilos 20 penny cut nails.

The building is 36 by 96 by 16 feet. From sills to plate tiers, 4 tiers; 13 feet from plate tiers to point roof, 2 tiers; all the tiers are 4 feet apart each way. This number of tier poles is enough when the tobacco is harvested by stalk. When the tobacco is harvested by priming, the number of tier poles is doubled in quantity by stretching heavy wire so as to alternate with the original tier. The building may be painted or not as desired.

In the Tropics; in Sumatra, Cuba and in the Philippine Islands, for example, the roofing and the sidewalls of curing sheds are made of light materials, like bamboo and nipa palms. The frames are, of course, made of strong lumber. The following is an estimate of materials used in the construction of one curing shed capable of curing a crop of 3 hectares under Philippine conditions:

DIMENSIONS OF BUILDING—50 M. X 20 M. X 3 M.

1. 40 ipil posts (6″ x 6″ x 12″)	₱280.00
2. 10 ipil center posts (6″ x 62″ x 25′)	140.00
3. 14 pieces apitong, for grits (3″ x 6″ x 30′)	42.00
4. 800 pieces big bamboo of rafters, beams, studs, wall frames and braces, door and window shutters, tier poles, etc., etc.	120.00
5. 12,000 nipa pingot (shingles) for roofing, walls and window and door shutters	100.00
6. 2,000 pieces splitted rattan for tying	20.00
7. 5 kilos of 5-inch nails	3.00
8. 5 kilos of 3-inch nails	3.00
9. 500 pieces, small bamboo for racks	20.00
10. Miscellaneous expenses	50.00
11. Labor construction	300.00
Total	1,078.00

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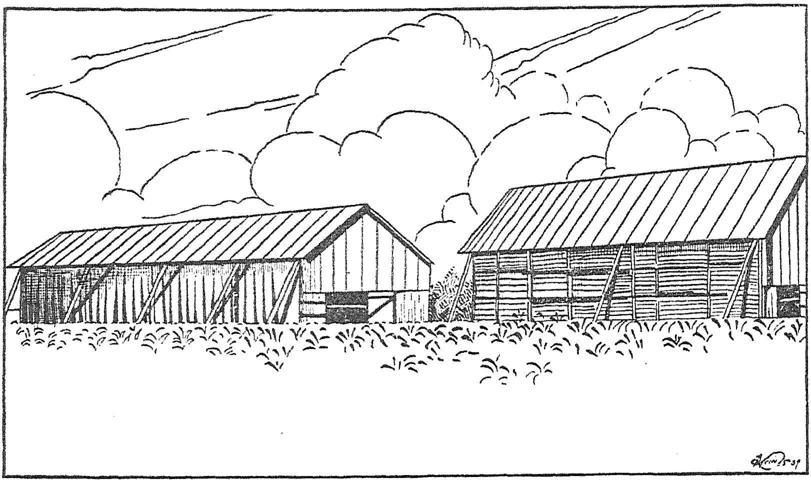

FIG. 3. Typical curing sheds for wrapper tobacco in the Connecticut Valley, U. S. A.

Poling and stringing.—When the leaves are brought to the curing barn, they are laid on the floor or table with great care to avoid folding, scratching, or mutilation. The fresh leaves are poled and strung immediately. If the crop is very uneven in size and soundness, it is first sorted for such soundness and size preparatory to stringing. The method of stringing and poling tobacco in Cuba and in the United States is similar. A big needle, a string, and a pole or lath are used. One end of the string is fastened to one end of the pole while the other end is attached to the needle. The needle is passed through the petiole of the leaf in such fashion that the leaves are strung face to face and back to back, allowing two fingers distance beween leaves. A pole four feet long usually contains from 36 to 45 leaves. When the pole is full, the end of the string is tied at the other end of the pole, stretching it well before tying. The strung and poled tobacco is then ready to be hung on the racks at a foot distance from one another for free circulation of air.

In the Philippines a pointed bamboo stick called "palillo" is used instead. The sticks are of different sizes, the big sticks for the big leaves and the small sticks for the small leaves. The sticks or palillos are provided with butts at one end to keep the tobacco from sliding off, and when the stick is full of tobacco, the other end, which is sharpened is corked with soft pitched wood or a slice of pummelo peel to prevent the leaves from falling off. To facilitate the sticking, a sword-like thim-

ble made of thin tin or other metal is inserted upon the sharp end of the stick. The thimble pieces the petiole of the leaves sharply without breaking them. The leaves are strung face to face and back to back with a finger's distance each. The method of poling and stringing wrapper tobacco in Sumatra is the same as that employed in the United States and Cuba.

Curing.—Curing is not mere drying of the leaves as most people think. The failure of most growers is due mainly to their utter disregard of the rules governing curing-shed operation or the absence of a suitable curing barn. Curing is essentially a life process. This is evidenced by the fact that the protoplasm of the leaf killed by excessively low or high temperature or by chemical treatment like chloroform prevents normal curing. Imperfect curing can not even be corrected by fermentation processes. The chemical changes which take place in curing are the properties of active substances. In a thoroughly air-cured crop, all the starch and reducing sugars disappear and there is a decrease of protein, nicotine, and total nitrogen content. Appreciable quantities of ammonia are formed in the process. The physiological processes during curing are brought about by the aids of diastatic, proteolytic, and deamidizing enzymes and probably also of oxidases. The starvation to which the leaves are subjected leads to an increased secretion of diastase. Thorough and gradual wilting during the initial stages of curing promotes the progress of the process, provided further curing of the leaf is not allowed to proceed too rapidly. Herein lies the danger of applying too much heat; therefore, the application of the same, if resorted to, must be moderate.

In tropical regions, wrapper tobacco is cured solely and completely by air in a slow, gradual manner. Freshly hung leaves are allowed to wilt by closing the ventilation for a period of 3 to 5 days, after which the ventilation is opened to allow free circulation of the air. After the wilting period the ventilation is opened every day except on windy and foggy days. In no case, however, should it be opened at night. Under Philippine conditions, curing is effected in from 24 to 32 days. In temperate countries, as in the Connecticut Valley in the United States, air-curing of wrapper tobacco is aided by artificial heat, either by charcoal braziers or a flue-heating system. This method of curing affords the only practicable means of preventing decay and the attack of leaf molds due to excessive moisture during cold weather. In other words, the curing of wrapper

tobacco in cold regions is accomplished by the combined use of artificial heat and ventilation. The application of heat is, however, rigidly regulated, and resorted to only when absolutely necessary.

Complex chemical reactions take place during curing. They cannot be fully explained at present because knowledge on this phase of chemical and physiological activity is rather scant. It is the general assumption that curing is the getting rid of at least 75 per cent of the water content of the fresh leaves, but this assumption is rather a makeshift explanation to cover the lack of proper understanding of the principles underlying the process of curing.

Before any tobacco is brought in to cure, the curing barn and its surroundings must be thoroughly cleaned, leveled, dried, and disinfected, if necessary. The cleanliness of the curing barn and its surrounding is here emphasized because the occurrence of fungus diseases due to dirtiness, damp soil, etc., often causes the destruction of a large portion of an otherwise good crop. The poled or strung tobacco is admitted and placed on the racks beginning with the highest series until the curing barn is full. To permit a slow wilting process, the ventilation is closed from three to five days. As the wilting period terminates, the yellowing stage begins, usually lasting from 7 to 10 days. The green color of the leaves gradually turns yellow; this change is regarded as the slow starvation of the leaves. The flow of air and the rate of yellowing must be regulated in order to allow a slow transformation. The last stage, that is, the turning of the yellow color to brown, emerges. This browning is due to the yellow pigment being oxidized by the action of enzymes found in the cell of the leaf. At this period the sugar and starch in the leaf disappear, together with some albuminoids and tannins, while the amount of nitrogenous bodies increases. The real drying now begins and must not be retarded until the sap of the midrib, which is the last to dry, is desiccated. The fixing of the color of the crop is also done at this stage. All ventilation should be opened daily, if weather conditions permit. When exigencies demand, the charcoal braziers or the heating system may be operated. Rapid drying is desirable to fix the color promptly, as an excess of moisture may likely blacken the crop. This stage lasts from two to three weeks. Ventilation should not be opened at night as the crop readily absorbs moisture to any amount, and this causes mold and decay. During the cur-

ing process the tobacco on the racks should be regularly shaken to throw off the worms that are feeding on the curing leaves. The last series of racks should be not lower than a meter from the dirt floor. If the barn is floored with either wood or cement, the lowest series of racks can be placed lower than a meter. This precaution prevents the leaves on the lowest racks from absorbing the moisture evaporating from the soil.

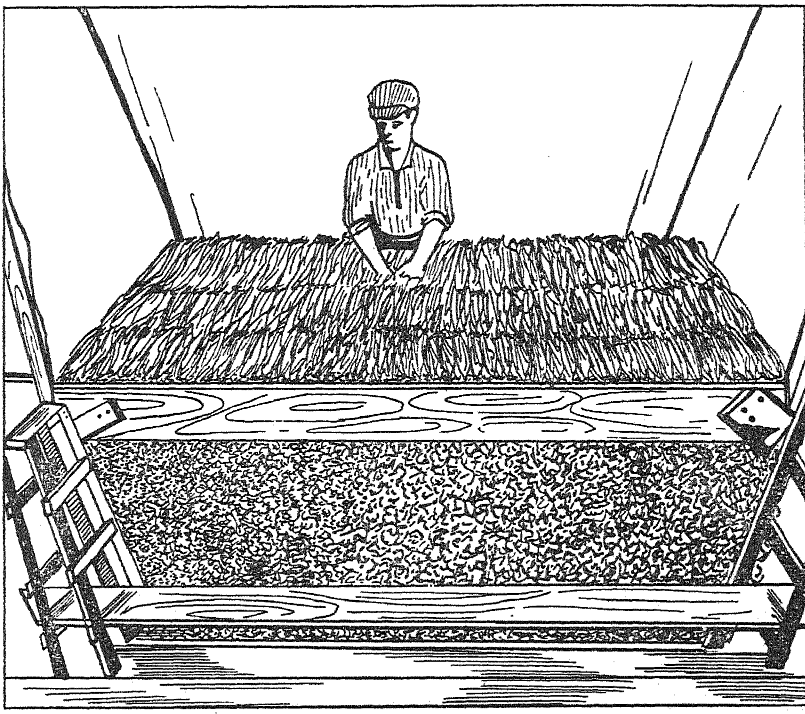

FIG. 4. Method of sweating wrapper tobacco in the United States

Fermentation.—The crop is ready for fermentation when the leaves are well dried and the midribs well desiccated. A thoroughly cured wrapper tobacco must also be in the proper condition or in "good order" before it can be fermented. Very dry tobacco, besides being too brittle to handle, does not develop heat and therefore, does not ferment readily, while too soft tobacco, when piled, is likely to burn due to the almost instantaneous development of excessive heat which moist tobacco can not withstand. Crops ready for fermentation should be neither too dry nor too moist, but must be pliant enough to permit handling. This condition can be easily determined by holding a fair-sized

bundle of the crop, pressing it firmly within the hand and then withdrawing the hold. If the bundle, upon being released, gradually unfolds and slowly returns to its former natural position, the tobacco is in good condition for fermentation. If the tobacco remains firm and intact when released, it is too soft for fermentation and should be allowed to dry until the desired

FIG. 5. A method of pilling wrapper tobacco in Sumatra for fermentation process

pliability is reached. Dry tobacco should never be sprayed with water or exposed to the open air for cooling, but should be hung in the curing barn either in the evening or early in the morning. When the crop is in "good order," it is removed from the poles or palillos and bundled into hands of convenient size. The sand leaves, standards, and tops are handled separately, and if the crop is large, fermented separately. A clean closed room, if a separate building is not available, should be used for fermentation. The crop is piled in bulks by sections and turned over regularly at least once for every 4 degrees rise in temperature. The object of turning is to reverse the construction of the pile,

bringing the top, bottom, and the outside layers into the middle of the new pile. For convenience, the pile should not be more than 2,000 to 3,000 pounds. It takes from 6 to 8 weeks to thoroughly ferment a crop. The object of fermentation is to make the crop more homogenous in color and to improve, mellow, and preserve it from decay. The changes that take place during fermentation, as per Table 8, are: (*a*) considerable loss of water and dry matter, (*b*) increase of ammonia, (*c*) decrease of nicotine, (*d*) disappearance of sugar, and improvement of flavor and aroma.

TABLE 8.—*Showing composition of 1,000 pounds of unfermented first wrapper leaves and the lose of each ingredient during fermentation (after Jenkins).*

Ingredients	In 1,000 pounds unfermented	Left after fermentation	Loss in fermentation
Water	275.0	226.2	48.8
Dry matter	725.0	683.1	41.9
Ash [1]	158.3	147.5	10.8
Nicotine	12.5	10.5	2.0
Nitric acid (N^2O^5)	25.9	21.3	4.6
Ammonia (NH^3)	3.3	4.3	[3] 1.0
Other nitrogenous matter [2]	113.1	105.6	7.5
Fiber	99.0	94.8	4.2
Other nitrogen:			
Free extract	255.6	244.5	11.1
Ether extract	28.4	26.4	1.8
Starch	28.9	28.0	0.9

[1] Free from carbonic acid and carbon.
[2] Nitrogen other than that of nicotine, nitric acid, and ammonia multiplied by 6¼.
[3] Apparent gain.

Contrary to the popular belief of the agency of bacteria in fermentation, Doctor Loew attributes fermentation of tobacco to the action of soluble ferments or enzymes formed in the growing plants and during the wilting period after harvest. He claims that in tobacco fermentation, the main changes are the result of chemical action wherein oxygen of the air is made to unite with the various compounds in the leaf. These oxidizing enzymes he calls oxidase and peroxidase. The oxidase, while a very active oxidizing agent, is readily destroyed or converted into ordinary protein at a temperature of about 152° Fahrenheit, while the peroxidase is more stable. Both, however, disappear after

sweating or after fermentation and upon aging. Other workers, however, believe that tobacco fermentation is due to the activity of bacteria which have the ability to produce heat during fermentation. According to Schmidt (1925) the mesentericous bacteria are found on Ohio tobacco of good quality, and the coccus form, on tobacco of poor quality. Experiments conducted by the Philippine Bureau of Science have also disclosed the fact that bacteria play an important rôle in tobacco fermentation. The petuning of tobacco in the United States has possibly no other purpose than to stimulate the growth of or to infect the leaves with the desirable bacteria. While the activity of nonliving ferments (enzymes) on tobacco fermentation cannot be denied, yet the rôle that bacteria play in tobacco fermentation is hard to ignore. It appears more logical to assume that both enzymes and bacteria activate if not altogether bring about, the result of fermentation.

In Cuba, the United States, the Philippines and Porto Rico, the methods of fermentation are virtually identical. In Sumatra, however, the method is so novel that it deserves a special mention.

The fermentation of a regular big crop of wrapper leaves from a single estate in the island of Sumatra is done in a series of gradual combinations of the fermenting piles or mandalas which are initially of small size. For convenience, let us call the series: A, B, C, and D. Each step in the series as a rule is characterized as to size and temperature allowed in each as follows:

A Series (first piles).—About 1,000 to 2,000 kilos of leaves are piled into bulks of 2.5 by 2.5 meters by about 30 layers and the temperature allowed is from 48° to 50° C. within 9 days.

B Series (second piles).—Each pair of A piles is now combined forming 3 by 3 meters by about 33 layers bulks with about 2,000 to 4,000 kilos of leaves and the temperature allowed to rise to 50°–54° C.

C Series (third piles).—Each pair of B piles is at this stage combined also, forming 4½ by 3 meters by about 40 layer bulks and the temperature further allowed to rise 54°–58° C.

D Series (fourth and last piles).—Lastly, each pair of C piles is combined to form 4.5 by 4.5 meters by about 50 layers or 3.75 by 5 meters bulks. The maximum temperature of 56°–58° C is the limit allowed to develop in this series.

Because of the tremendous amount of the crop, many piles are naturally made under each series. And the piles under the first

or A series are designated thus: A–1, A–2, A–3, A–4, etc. The whole process may last from 45 to 75 days.

The foregoing method ought to be a sound practice inasmuch as it is universally followed in that famous island but our own experience in the Bureau of Plant Industry stations where it is impossible to raise wrapper tobacco in a commercial scale, has shown that small piles about 2.5 meters square and the height the equivalent of about 30 layers of hands, can be allowed to heat to 56° C. and even to 58° C. with satisfactory results.

Classification and sorting.—Many a good standing crop is spoiled for the market by improper sorting and classification. Classification requires skill, and experienced sorters on a tobacco estate are indeed a great asset. As the tobacco cannot be handled when brittle, the sorting is deferred until the cool season begins, when the crop is pliant enough to be handled. A well lighted or ventilated room is the proper place for classification work, as the different shades of color can thus be easily distinguished. A sorter squats on the floor with his back towards the light. In front of him is a fence of sticks or boards arranged in a semi-circle with convenient spaces between the sticks where the classified product is laid in piles. Every space corresponds to a grade or class. Beside the sorter is a pile of the unclassified crop. The sorter takes a bundle, examines it leaf by leaf and places each leaf in its particular section. A glance is sufficient for an experienced sorter to decide to which class a leaf belongs. The various shades of color are easily differentiated by a trained eye. Slight variations in color are, however, less important as a basis in sorting than quality evidenced by fineness of texture and light uniform color combined with strength and elasticity. Whenever a sorter is undecided as to which of two grades a leaf belongs he invariably places the doubtful leaf in the lower grade. This practice assures the maintenance of a high classification standard which is absolutely necessary in order to preserve the good reputation of the grower. The sorted crop is then graded according to length. All leaves 15 or more inches in length are classified as first class in length; those of 12 or over but not more than 15 inches are second class; those of 10 or over but not more than 12 inches are third class and those of 8 or over but not more than 10 inches are fourth class. The sorted leaves are finally rebundled in convenient sizes in fan-shaped fashion and are piled grade by grade and left thus until baled.

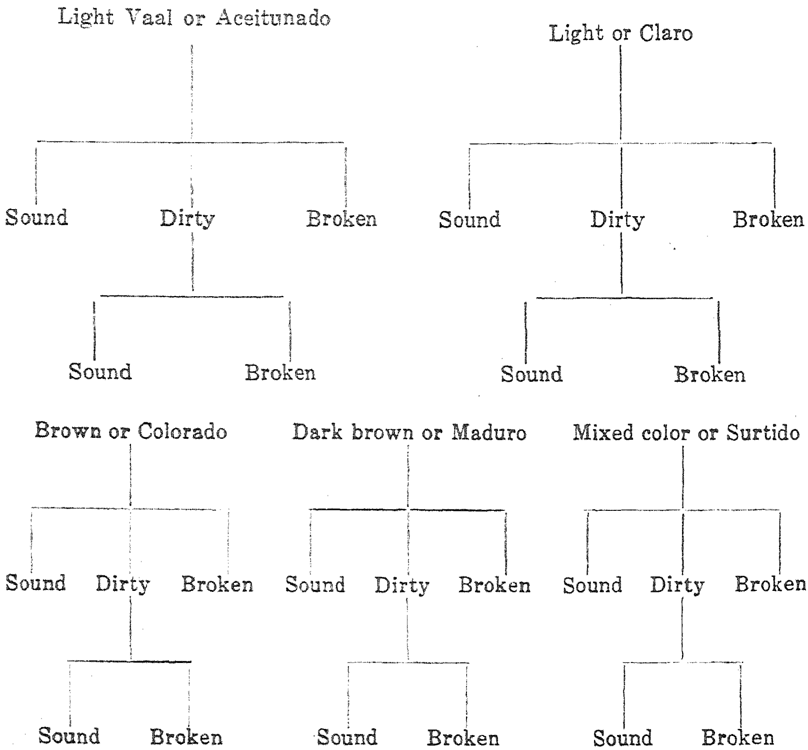

DIAGRAM 2.—Showing classification of wrapper tobacco according to soundness and color.

Abbrevations:

Lv	Light vaal or aceitunado.
L	Light or claro.
B	Brown or colorado.
BB	Dark brown or maduro.
S	Mixed color or surtido.
X	Sound.
Y	Dirty.
Z	Broken.

Classification as to length:

First	15 inches or more.
Second	12 inches and less than 15 inches.
Third	10 inches and less than 12 inches.
Fourth	8 inches and less than 10 inches.
Fifth	all leaves below 8 inches.

In wrapper tobacco classification, the principal criteria are soundness, color, size, fineness, and strength in the order of their importance. As a guide in sorting the diagram of wrapper tobacco classification on this page may prove helpful.

It is unfortunate that the Philippines does not have as yet and official classification or standards for locally grown wrapper

tobacco. The accompanying diagram 2 is proposed by the writers under Philippine conditions. Realizing, however, the tremendous importance of the matter and in order that the authorities or offices concerned can have actual basis for the preparation of Philippine cigar wrapper standards that will meet universal acceptances, appendices A, B, and C are included in this article showing in full the accepted and official standards and baling methods of Sumatra, Cuba and the United States.

Baling.—The product ready for shipment is packed and pressed in grass or palm mats, each bale containing 50 to 80 kilos and measuring 30 inches square and a foot thick. The method of baling is as follows:

A wooden or iron receptacle, consisting of four loose sides without cover, is placed under the press. The mattings are placed at the bottom of the receptacle before the sides are attached. Then the box is filled with tobacco that is already weighed and pressure is applied on the top by means of an iron plate and a screw-like lever. The iron plate presses the tobacco until the desired thickness is reached. The sides of the box are removed and the matting placed and sewed with the aid of iron pins. The pressure is released and the package or bale of tobacco is rolled out and labeled accordingly. The bales are stored in the warehouse, where they are fumigated with carbon bisulphide gas to protect them from the attack of beetles. The tobacco is then ready for shipment or for immediate sale.

Stocks of fine grade wrapper tobacco are sometimes stored in ice plants or in sealed tin containers.

VII. YIELD, COST OF PRODUCTION, MARKETS, THE FLOW OF TRADE, AND THE PROSPECTS OF THE INDUSTRY

The success of growing wrapper tobacco depends largely upon the grower's experience and his ability to keep the cost of production within bounds so as to avoid useless and unnecessary expenditures, particularly under shade culture where the outlay of expenses is very high. Every detail of the work in the field and in the barn must be performed thoroughly, as oftentimes the least neglect results in irreparable loss. Burying the tent posts one inch shallower than is necessary may cause the collapse of the whole structure when struck by a gale of wind. In the purchase of shading materials and fertilizers, it must be borne in mind that the cheapest materials are not

in most cases the best. Beginners should start on a small scale, on an area of a single acre or a hectare. As experience is acquired and the grower becomes familiar with the details of field and barn operations, the area can be gradually increased.

YIELD AND COST OF PRODUCTION

The cost of production of wrapper leaf tobacco as seen in Table 9 varies in different countries, depending upon the standard of living, scarcity or abundance of labor, and the cost of shading materials and fertilizers.

TABLE 9.—*Showing cost of production per hectare of wrapper leaf tobacco in the four principal wrapper-tobacco-producing countries of the world*

(1) SUMATRA—SUN-GROWN CULTIVATED BY BANKING (UNDER PHILIPPINE CONDITIONS)

1. Preparation of land (clearing, 2 plowings and digging of cannals)	₱135.00
2. Curing shed and laborer's quarters	685.00
3. Tools including sprayers	50.00
4. Seedbed materials, palillos, and others	100.00
5. Worm control including cost of insecticide	80.00
6. Rearing 25,000 plants from seed bed to maturity	400.00
7. Harvesting and stringing	150.00
8. Curing and bundling	35.00
9. Fermenting	15.00
10. Classification, leaf by leaf	200.00
11. Baling and baling materials	40.00
12. Incidentals	100.00
13. Capataz supervision based on a hectare unit	60.00
14. Direction based on a hectare unit	60.00
Gross cost per hectare	2,010.00
Minus cost of buildings and equipment after deducting corresponding yearly depreciation	625.00
Net cost per hectare	1,385.00

(2) CUBA—SHADE-GROWN BY USING CHEESE CLOTH

1. Fertilizers	₱320.00
2. Cost of 40,000 seedlings	120.00
3. Preparation of field	80.00
4. Transplanting expenses	60.00
5. Cultivation	150.00
6. Irrigation	70.00
7. Topping, suckering, worming	80.00
8. Harvesting	40.00
9. Curing, poling, and stringing	200.00
10. Depreciation of barn	80.00
11. Depreciation of cheese cloth (50%)	400.00
12. Depreciation of other shed materials	40.00
13. Labor for erecting of tent and removal after harvest	300.00
Net cost per hectare	1,940.00

(3) UNITED STATES—CONNECTICUT VALLEY SHADE-GROWN (USING CHEESE CLOTH ALSO)

1. Interest of one hectare of rented tobacco land	₱72.00
2. Interest and depreciation of farm barn	120.00
3. Interest and depreciation of tent frame	64.00
4. Repairs of tent frame	19.00
5. Cloth to cover frame	731.00
6. Placing cloth on frame	32.00
7. Production of seedlings	70.00
8. Fertilizer	267.00
9. Fertilizer application	5.32
10. Preparation of land	34.74
11. Transplanting	38.32
12. Restocking and poisoning	48.00
13. Cultivation	41.00
14. Topping and suckering	33.60
15. Repairs to tent during season	37.68
16. Straightening of tobacco after storm	4.00
17. Remodelling of barn	30.00
18. Twine	7.24
19. Poling and stringing	92.84
20. Priming and hanging of leaves	225.20
21. Curing and prevention of pole sweat	34.04
22. Delivering tobacco	9.32
23. Removing of cloth and frame after season	19.00
24. Cutting stalks and cleaning the fields	32.64
Net cost per hectare	2,067.94

(4) PHILIPPINE ISLANDS—SHADE-GROWN USING BAMBOO AND PALM LEAVES AS SHADE

1. Seedbed and rearing of seedlings	₱8.00
2. Preparation of field	25.00
3. Transplanting	16.00
4. Cost of shading materials	200.00
5. Erecting shade tent	40.00
6. Worming	20.00
7. Cultivation	15.00
8. Priming and poling	80.00
9. Curing and fermenting	15.00
10. Classification and fermentation	200.00
11. Baling and baling materials	25.00
12. Depreciation of curing shed	60.00
13. Miscellaneous expenses	100.00
Net cost per hectare	804.00

Sumatra wrapper.—In the island of Sumatra, where the famous Sumatra wrapper is raised, the cost of production per hectare is about ₱1,500. Considering the apparently cheap labor of this Dutch colony, this figure seems rather high, especially, since the shelter tent method of growing tobacco is never practiced there. The main reason for this seemingly high cost of production is that all field operations are carried out by manual labor. Not even animal power is utilized. The Suma-

tra triangular method of planting tobacco and its cultivation by the so-called "banking" system is so laborious and expensive that only the presence of cheap coolie labor permits the adoption of this method of growing wrapper tobacco. The outstanding characteristic of the Sumatra method is the laying out of deep canals after every two or more rows of tobacco planted triangularly, thus forming plant beds. The soil dug from the canals is deposited on the plant beds between the plants, gradually raising them. These canals are sometimes about a meter deep from the surface of the raised beds. For every five or more of plant beds larger canals are built for the exit of the small canals, so that the whole canal system resembles trenches. It is built entirely by manual labor with the aid of hoes and shovels. The advantage of this method of growing wrapper tobacco over the shade system is hard to explain but most assuredly the canals serve as a complete drainage system for the plantation. It seems probable that because of the almost even distribution of rainfall throughout the year in the Sumatra tobacco district there is need of getting rid of an excess of water that might otherwise flood the whole tobacco plantation, hence the deep canals. An attempt has been made in the Philippines to imitate this method, and a certain tobacco company with farms in the Cagayan Valley even went to the extent of hiring laborers from Java to work on the tobacco plantations. The results, however, to date are very discouraging and the company is on the verge of giving up the venture. Differences of climate, soil, and wages in the Philippines and in Sumatra are big factors affecting the advisability of this system in the Philippines. Besides, the growing period of tobacco in the Philippines falls in the summer months, so that the problem is not one of how to get rid of water but of how to conserve it. The banking method of cultivating tobacco accelerates soil evaporation through the exposed banks of the plant beds, and therefore deprives the plant of what little water there is in the soil for its nourishment. Except possibly Sumatra and Java, which are successfully producing wrapper tobacco that is among the best in the open culture by the so-called "banking method," everywhere else most wrapper tobacco is grown under shelter tents. What is also important to bear in mind is that Java and Sumatra have not become famous producers of filler or cigarette tobacco and have no local factories, whereas the other tobacco-producing countries, in addition to their wrapper product, produce nearly all

other kinds of tobacco products,—cigar filler, cigarette filler, chewing, lug, smoking, etc.

Under Sumatra conditions a hectare of wrapper tobacco produces an average of from 10 to 13 quintals of marketable wrapper of various grades. When one considers that high-grade Sumatra wrapper sells as high as ₱30 a kilo, one is apt to assume that a tremendous profit is made by the producers. This profit is more apparent than real, because besides the cost of production there is the expense of shipping the crop from the Dutch East Indies to Europe, and before the crop reaches the factories it has to be shipped to the importing country where tariff duty must be paid in addition.

Cuba shade-grown.—Cuba may well be considered the island home of the best cigars in the world. American capital invested in the tobacco industry of Cuba and the progressive American method of tobacco culture and manufacture effected a rapid improvement in the tobacco industry of Cuba. The system of growing wrapper tobacco under shelter tents in Cuba is due to American influence. The cost of production amounts to about ₱2,000 per hectare. This apparently high cost of production is due mainly to heavy costs of fertilizers and shading materials which are imported from the United States. A hectare yields from 1,000 to 1,500 lbs. of marketable wrapper of various grades and a bale of 80 to 90 pounds of fine Cuban wrapper sells as high as ₱200 to ₱1,000. A good portion of the Cuban wrapper is exported to the United States, while the rest is utilized locally for the manufacture of Havana cigars which are exported to all parts of the world. Cuban cigars, more often termed "Havanas," are famous the world over because of the high quality of the filler tobacco.

United States shade-grown wrapper.—The Connecticut Valley and Georgia and Florida are the wrapper-tobacco regions of the United States. The most scientific methods of culture are practiced there, and money is not spared to produce the finest crop. No crop is more heavily fertilized in the United States than tobacco, and, in the production of wrapper, the use of the shelter tent is in vogue. The average cost of production per hectare is over ₱2,000, but in spite of heavy expenditures, the wrapper-tobacco industry of the United States so far is considered one of the most profitable farming enterprises of the American farmers. For a better conception of the wrapper production of the United States and the prices offered for it,

Table 10 is hereby presented, showing the average yield per acre, total production, price per pound, value per acre, and total farm value from 1919 to 1931, inclusive.

TABLE 10.—*United States wrapper-tobacco production and prices, 1919–1931*

NEW ENGLAND SHADE-GROWN, TYPE 6

Year	Average	Yield per acre	Production	Price per pound	Farm Value	Value per acre
	Acres	*Pounds*	*1,000 pounds*	*Cents*	*1,000 dollars*	*Dollars*
1919	4,900	1,178	5,772	105.0	6,060	1,236.73
1920	6,000	899	5,393	100.0	5,393	898.83
1921	7,400	1,019	7,543	95.0	7,166	968.38
1922	8,000	849	6,792	90.0	6,113	764.12
1923	8,500	1,134	9,639	100.0	4,830	1,050.00
1924	6,900	1,070	7,385	85.0	6,277	909.71
1925	4,600	1,050	4,830	100.0	4,830	1,050.00
1926	5,300	1,004	5,322	97.8	5,204	981.89
1927	7,100	899	6,386	105.0	6,705	944.32
1928	8,000	865	6,923	100.0	6,923	865.38
1929	8,700	1,174	10,215	95.0	9,704	1,115.40
1930	7,400	1,042	7,712	90.0	6,941	937.97
1931	5,800	982	5,693	80.0	4,554	789.17

GEORGIA AND FLORIDA SHADE-GROWN, TYPE 62

Year	Average	Yield per acre	Production	Price per pound	Farm Value	Value per acre
1919	3,600	1,114	4,012	65.0	2,608	724.44
1920	3,400	1,118	3,800	60.0	2,280	670.59
1921	3,100	1,011	3,135	60.0	1,881	606.59
1922	3,400	1,092	3,714	50.4	2,872	550.59
1923	3,600	1,183	4,260	58.0	2,471	686.39
1924	3,000	1,019	3,058	60.0	1,835	611.67
1925	1,900	1,100	2,090	65.0	1,358	714.74
1926	2,300	1,124	2,586	65.0	1,681	730.87
1927	2,800	1,213	3,396	65.0	2,208	788.57
1928	3,500	1,114	3,900	55.0	2,145	612.86
1929	3,700	1,182	4,373	55.0	2,405	650.00
1930	3,400	1,115	3,790	60.0	2,274	668.82
1931	2,700	1,069	3,101	50.1	1,554	535.86

The above table shows that in 1931, the United States planted about 8,500 acres of shade-grown wrapper tobacco with a total production of about 8,794,000 pounds, valued at $6,108,000. The average yield per acre is about 1,025 pounds with a value of about $662.51 or an average of 65 cents a pound. The Connecticut Valley, which constitutes the major portion of the New England States, produces more and better crops than Georgia and Florida.

Philippine Islands shade-grown wrapper.—The commercial production of shade-grown wrapper in the Philippines is a new undertaking which was started about six years ago in the Cagayan Valley and later introduced in the Province of La Union where it gained a better foothold. La Union Province produces a greater bulk of shade-grown wrapper than any other province of the Islands. The materials used for shading the plantation are either coconut palm leaves or talahib grass (*Sacharum spontaneum*). The cost of production ranges from ₱500 to ₱1,000 per hectare, a hectare yielding from eleven to sixteen quintals of marketable wrapper of various grades. Prices range from ₱0.50 to ₱12 a kilo. The fact that about three years ago the Philippines imported about ₱1,500,000 worth of wrapper from abroad and today only about ₱500,000 is an indication that the industry is prospering, and very soon the country will become self-supporting in her wrapper leaf tobacco needs.

Philippine open-grown wrapper tobacco.—At present and as just pointed out, commercial open cultures of wrapper tobacco in the Philippines are found only in one or two haciendas in Isabela Province. But chiefly because of variable weather conditions, these may eventually be given up. The production of wrapper tobacco in open culture in the Philippines, however, is not entirely hopeless. As may be gleaned in Table 2, there are Philippine regions with climatic conditions virtually identical with those of Sumatra. Although the first attempts in the Cotabato Valley were given up, cultures have been started recently in Davao, Samar, and Negros Occidental.

Even in the Cagayan Valley, although it is not practical to raise a pure wrapper crop in open cultures, by planting the local varieties, especially the Vizcaya, in the field closer (80 centimeters between rows and 70 centimeters between plants in the rows) as high as 15 per centum good wrappers may incidentally be produced from the regular cigar filler tobacco crop.

MARKET, THE FLOW OF TRADE, AND THE PROSPECTS OF THE INDUSTRY

The methods by which growers dispose of their crop vary widely in different countries and even in different regions within a country. In the United States, the auction or loose-leaf floor system; the hogs-head market; the county sales, and the cooperative marketing systems are in vogue. Tobacco crops of

the Dutch East Indies are shipped first to the mother country in Europe where sale is effected by auction in Amsterdam and Rotterdam. During the auction season, representatives of various tobacco firms all over the world gather in Amsterdam and Rotterdam to buy the famous Sumatra wrapper crop. In the Philippine Islands the buying of tobacco by the so-called "papeleta" system, that is, buying tobacco without cash but with the buyers issuing a sort of certificate of sale contract instead, has been practiced for centuries. This method of buying tobacco in the Philippines has been the source of countless difficulties between buyers and producers, and the farmers have in most cases been the victims. Producers sometimes have to wait years for payments for their crop. This disagreeable practice was denounced by the Philippine Government sometime ago and the coöperative marketing system was inaugurated through the efforts of the Bureau of Commerce. The progress of this new movement has been necessarily slow because of the indifference and ultra conservatism of the tobacco producers, but as the farming masses gradually become more intelligent and realize what the Government is trying to do for them, this coöperative marketing system will ultimately succeed.

In many of the cigar leaf districts, however, in countries like the United States, Cuba, and the Philippine Islands, the sale of the crop is consummated on the farm. Buyers or their representatives visit the plantations to determine the approximate quantity and to appraise the quality of the crop, and contracts are entered into between the producers and the buyers. The movement of the tobacco product is international, moving from one country to another. The United States alone imports Sumatra wrapper running to about 5,000,000 pounds annually. At the same time, however, she exports part of her wrapper production to other countries. The Philippines is at present an importer of Georgia and Sumatra wrapper tobacco, her importations running to as much as ₱300,000 annually for United States wrapper and ₱109,206 annually for Sumatra. Table 11 gives an idea of the imports of the United States from foreign countries and from her possessions.

As seen from Table 11 the United States import enormous quantities of Sumatra wrapper, buying over 5,000,000 pounds annually, besides her wrapper imports from other countries,

TABLE 11.—*Imports of cigar leaf tobacco by the United States from foreign countries and possessions*

Product and country from which imported	1923	1924	1925	1926
CIGAR WRAPPER	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Netherlands	7,485,000	5,821,000	6,261,000	6,261,000
Other countries	233,000	73,000	174,000	228,000
Total	7,718,000	5,894,000	6,435,000	6,489,000
OTHER CIGAR LEAF				
Philippine Islands	1,931,000	1,231,000	1,166,000	908,000
Cuba	20,422,000	19,040,000	21,133,000	22,562,000
Puerto Rico	17,838,000	16,370,000	20,258,000	27,261,000
Other countries	5,031,000	3,591,000	163,000	110,000

possibly from Cuba and Puerto Rico. Besides wrapper the United States also imports a large quantity of other cigar leaf tobacco, notably filler and binder, from the Philippines, Cuba, and Puerto Rico. European countries are also heavy importers of wrapper and filler tobacco, mostly from Sumatra, Cuba, the Philippines, and Brazil. There is no other farm crop more heavily taxed and rigidly regulated in its movement than tobacco and its manufactured products. Customs duties, surtax, turnover tax, excise tax, and privilege tax of leaf tobacco dealers and manufacturers are some of the Government charges on tobacco and its manufacture. Tobacco import duties are very high and vary in different countries from 10 per cent to 100 and more per cent ad valorem. Even the internal movement of tobacco and its manufacture in the country where it is grown and elaborated is rigidly regulated and taxed by the government. Yet, in spite of all these impositions and regulations, the tobacco trade flourishes.

To visualize the future of the wrapper tobacco industry of the world, it is important to survey the reaction of the tobacco-consuming public to the different manufactured tobacco products. Before the World War the cigar was the most important product of the tobacco-manufacturing industry. The five-cent cigar was then the pillar of the cigar industry. During the period of prosperity, even the ten-cent and twenty-cent cigars were fast sellers. Then the decline came and the cigarette industry expanded by leaps and bounds until it now predominates

in volume over the various manufactured tobacco products in international trade.

The United States alone increased her cigarette area to nearly 78 per cent of her total tobacco area during the period from 1926 to 1930. Her smoking, chewing, and snuff tobacco decreased 10 per cent in acreage, and from 30 to only 15 per cent of the total area. The cigar types lost 23 per cent in acreage and dropped from 16 per cent to only 7 per cent in relation to the total tobacco area. It appears that tobacco consumers switched to the less expensive products during the period of economics stress. Even the Philippine Islands recently embarked on the production of cigarette tobacco, and her cigar leaf (filler) areas have been gradually decreased to give way to crop diversification. No one can predict with certainty what the future fashion in smoking will be. The cigarette craze may become permanent. Other modes of consuming tobacco may arise; but whatever the future brings, the cigar will continue to be the most valued and the most aristocratic product of the tobacco-manufacturing industry, and as long as this is true, the wrapper-tobacco industry will also persist. During economic depressions there is a tendency among smokers to use tobacco in its less expensive forms, but when normal times return the first yearning of smokers is for the aristocratic cigar.

VIII. TOBACCO PESTS AND DISEASES

The production of high yielding and good quality tobacco has become more difficult in spite of the increased knowledge acquired by growers through experience and experimentation. This difficulty is in a great measure due to the increasing prevalence of tobacco pests and diseases. While new areas for tobacco culture are being opened, the important tobacco districts of the world remained unchanged in location, which simply means that a greater portion of the total area planted to tobacco is intensively and continuously planted to this crop every year. Diseases and pests in these constantly used soils naturally accumulate. It is hard to make an exact estimate of the damage done by diseases and pests to the tobacco industry, but one can get an idea of how tremendous it must be when it is considered that in the United States the loss due to root-rot alone in a certain year amounts to about ₱20,000,000. It is conserv-

atively estimated that the United States losses about ₱50,000,000 of the total value of her tobacco crop annually. In the Philippine Islands, in the province of La Union, approximately one-third of the supposed normal production is being destroyed by the tobacco wilt disease, which means a loss of about ₱800,000 yearly to the province. The most common diseases and pests of tobacco are hereby enumerated, together with causes, when known, and the possible methods of control.

TOBACCO PESTS

From a survey of the various available papers on tobacco insect pests it appears that in tropical as well as in semitropical tobacco regions the damage done by insects is considerably greater than in temperate regions, like the Connecticut Valley. Insect attacks begin almost as soon as the seedlings appear and do not cease until the tobacco is consumed. The damage is mainly of four kinds and may be classified in the following manner:

1. Injury to roots and stems;
2. Leaves eaten or ruined;
3. Leaves punctured by sucking insects;
4. Dried tobacco eaten.

Cutworms.—These insects do vastly more damage to tobacco than all others put together, making it necessary to reset the field or to set nursing plants many times. The latter plan tends to give the crop uneven maturity and quality at harvest.

Cutworms are caterpillars of a number of species of the owlet moth, belonging chiefly to the genera *Peridromia, Agrotis, Feltia, Chloridea, Plusia* and *Prodenia.* Most species have but one brood a year. The eggs are laid on grasses late in summer. The worms as they hatch feed on plants, going deeper into the soil as colder weather comes. In the spring they come out and feed on plants of many kinds. Later they take on the chrysalid form in the ground and emerge as moths. The worms feed at night and spend the day in the ground or under clods or rubbish. In the Tropics their life cycles are virtually uninterrupted. The caterpillar of the genus *Chloridea* is better known as the false bud-worm.

Late fall plowing uncovers many worms which are eaten by birds, and also kill the plant growth which is their early spring food. Undoubtedly rye and other cover crops favor their presence in the field. The best poison bait for them is one pound

Paris green to 100 pounds of bran, a pint or more of molasses and enough water to moisten the whole which is thoroughly mixed. The mash is strewn over the field a few days before setting or placed on rows where the plants are to set. This will kill most of the worms which are ready to attack the crops.

Some growers have found it worth while to put a pinch of this mash near each plant when set and claim that it gives perfect protection. This, however, involves a great deal of labor.

In the Tropics as discussed in a preceding chapter, hand picking is the most practical means of control especially when labor is cheap and abundant. One to two per cent solution of either calcium or lead arsenate spray in the seed beds and in the growing plants in the field, is also practical specially when labor is rather scarce or expensive. Dusting with the same insecticides is preferable as the plants become older.

A parasitic hymenoptera (*Microphitis* sp.) attacks the larvae of the genus *Chloridea* while those of the *Prodenia* by a tachnid fly. A hemipterous insect (*Enagoras* sp.) attacks the larvae of both genera.

Wire worms (*Melanotus cribulosis* Lee and Asaphes *sp.*).—These are the larvae of the click beetles (*Elateridae*) and unlike cutworms can work their way into hard vegetable matter. Occasionally they do serious damage to tobacco, attacking both the roots and the base of the stem. The worm lives for at least three years underground, transforming there after midsummer of the third season in earthen cells. The adult beetles emerge the following spring.

The only suggested remedy is stirring the soil in late summer and fall, which breaks the cells and kills many of the adults. In Cuba drenching the furrows at planting time is the method used to check the pest.

Tobacco horn worms (*Acherontia lacherus and Phlegethontius quinquemaculata* How.).—These worms, the caterpillars of sphinx or hawk moths, are more destructive than any other insect attacking tobacco, excepting cutworms in the United States. The eggs are laid singly on the under side of the leaves by the adults which fly only at dusk. The egg hatches seldom before July into a worm or caterpillar which eats tobacco leaces voraciously until harvest time. The fully grown caterpillar goes into the ground and assumes its pupae or chrysalid form a few inches below the surface to emerge as a moth the next spring. An important natural enemy is a small four-winged fly which

lays eggs in the worm. Its larvae develop there and fasten their cocoons on the back of the caterpillar. A worm thus attacked dies before transforming.

The only control practiced in Connecticut is hand picking. German of Kentucky has shown that one pound of Paris green in 160 gallons of water does not injure the leaf and spraying is practiced somewhat in Kentucky and also in Florida where lead arsenate is used which cannot kill the leaves and adheres to them better than Paris green. In the Tropics the larvae of the sphynx moth is held in check by certain parasitic flies.

Grasshoppers, tree crickets, etc.—Tobacco is often severely damaged by various species of *Orthoptera*. The leaves injured by grasshoppers have holes in them, or perhaps the edges are eaten, the injury being larger than flea-beetle injuries, but usually smaller than thos caused by horn worms.

As a rule the plants on the outside rows, specially when near grass, weeds, or brush, are damaged more seriously than the plants in the center of the field. Certain of these insects make their way to the middle of the field and there feed upon the plants, like the Carolina locust (*Dissosteira carolina*, Linn), the common brown species. The red-legged grasshopper (*Melanoplus femur-rubrum* DeG.) is common in Connecticut, and has been observed feeding on tobacco. *M. atlantis* Riley and *M. differentiales* Thos, have also been reported as feeding on tobacco in Southern United States.

Tree crickets are sometimes injurious around the edges of the field. The commonest is the four-spotted tree cricket (*Oecanthus quadripunctatus* Bent) though the striped tree cricket *O. fasciatus* Fitch, is also found feeding on tobacco.

Other species of *Orthoptera* attacking tobacco in Connecticut are the Texas katydid, *Scudderia texensis* Sanspictet; *S. septentrionalis* Serv; slender meadow grasshopper, *Xipidium fasciatum* DeG, and the short-winged meadow grasshopper, *X brevipenne* Scudd.

Tobacco stem borer (*Gnorimoschema heliopa*).—This is a very serious pest of tobacco, attacking mostly young plants and water sprouts. The young larvae bore throughout almost the entire length of the young stem which eventually swells.

Obviously the stem borer cannot be controlled by poisons since it is well hidden but by insuring the rapid growth of the seedlings thus minimizing their life in the seed beds, infestation is likewise minimized. In the field, vigorous plants can survive an

operation with a sharp knife to kill the larvae. Otherwise the plants that are badly infested should be removed and destroyed.

Tobacco splitworm [*Phthorimeae* (*Gelechía*) *operculella* Zell.].—This insect is an important pest in Southern United States. The adult insect is a minute, grayish moth laying its eggs upon the leaves. The minute caterpillar bores between the surfaces of the leaf making a flat mine, often of considerable size with a gray discoloration visible from both sides of the leaf. There are two or more generations in the course of the summer, and the insect is more noticeable in the autumn.

It has been shown that in Florida this leaf miner when feeding, does not pass its entire life in one place, but after a while gnaw to the outside, and then crawling around over the leaf, will finally enter the tissue again in a new place. From this habit of the insect, it can be controlled by an arsenical spray. The fact, however, that the early generation of the insect is passed in some other food plants like the horse nettle and possibly, the nightshade and the jimson weed, it is recommended that these weeds be destroyed. Clean culture is also advisable.

The new tobacco bug or suck-fly (*Dicyphus minimus* Uhler).—This insect is not only new as a tobacco enemy but is new to science. In Florida, it is considered as a serious enemy of the crop. While the first crop may not be generally damaged, the second as well as late tobacco crop are frequently quite destroyed.

The insects damage the leaves by sucking the cell sap through their beaks. The infested leaves soon become yellowish in color and somewhat wilted, and the older leaves eventually split in places. These conditions render proper curing difficult if not impossible.

The eggs are deposited singly, mainly in the smaller veinlets, hatching after about four days. The entire life cycle of the insect is supposed to be only about 15 days.

A thorough cleaning up of the fields and burning of the trash in autumn are measures which should be adopted when the insects are abundant. The Florida Agricultural Experiment Station has found that a concentrated solution of nicotine, diluted with sixty parts of water, will kill a large proportion of the full-grown as well as many of the young. Spraying should be done in the morning when the insects are less active. Early set trap plants may concentrate the hibernating bugs, so that they can be readily killed.

Other sucking bugs (*Stink bugs*).—There are several true bugs known to suck tobacco juices, causing a shrivelling or drying of the leaf but so far none have been observed to be important enemies of the tobacco crop.

One of the commonest of these bugs is *Precilacystus diffusus* Uhler. This insect is found at all seasons of the year and it really becomes a little menace when very abundant. Another species is the green bug, *Euschistus variolarius*. It has been reported as quite important in Kentucky. An interesting little bug of the family *Scutelleridae, Corimelaena extensa*, has been found of little importance also at Cedar Ranch, Arizona.

It is possible that in the course of time either by a developing habit or by an increasing abundance of any or all of these bugs, they may become very important pests of tobacco. At all events, the bugs may be controlled by the same remedies as recommended against the "suck fly."

The Bud worms (*Heliothis rhexia* S. *and* A. *Heliothis armiger* Hubn).—These are two distinct and rather similar insects known as bud worms, occurring frequently together in the same field.

The true bud worm, *Heliothis rhexia*, thus far, is found only to occur in the Southern States and the Tropics. The adult insect is a small greenish moth. Its caterpillar is nearly always found in the bud of the tobacco plants about the time of topping. They are usually late in their appearance, that is, they are most likely to be damaging toward the latter part of the tobacco season. The insect feeds on other plants, mostly of the nightshade or solanaceous group.

The false bud worm, *H. armiger*, sometimes called "fall worm" is not distinctly a tobacco insect, attacking the tobacco only when its favorite food plants are not abundant. The insect prefers cotton, tomato and corn especially.

The insect is rather variable, its worms varying from light green, without spot or stripe to nearly black in color. When attacking the tobacco plant, the buds are the principal parts damaged although the leaves are also eaten to a certain extent.

The arsenical spray recommended for flea-beetles is applicable to the control of these bud worms but in Florida, Prof. Quaintance recommends the sprinkling in the bud of a thoroughly mixed fairly finely ground corn meal (a quart) and Paris green ($\frac{1}{2}$ teaspoonful). Clean culture, careful attention to corn and tomatoes growing in the vicinity and late fall plowing to break the little earthen pupae cells of the insects are recommended.

Other tobacco leaf and stem feeders.—The so-called cabbage looper, *Autographa brassicae* Riley, is a noctuid moth which in the larval stage feeds chiefly on cabbage and related plants but has been found in Maryland tobacco fields, although not in sufficient number to make it important. The particular species is readily destroyed by the arsenical spray.

Mamestra legitisnea is an insect which is allied to the cutworms and feeds exposed upon the foliage of different plants. Its larva is a very handsome caterpilar, bright yellow in color, with velvety-black longitudinal lines. Thus far it has only been observed as a tobacco insect in southern Virginia. It is also easily destroyed by the arsenical spray.

The tobacco thrips (*Thrips tabaci* Lindemann).—This minute insect is primarily an onion pest, and attacks the tobacco in Europe. Recently there has appeared in Florida, Georgia, and Texas another species of thrips (*Euthrips nicotianae* Hinds), which according to Hooker of the U. S. Department of Agriculture Bureau of Entomology does much damage to shade grown cigar wrapper tobacco by sucking out the sap from the veins on the upper surface of the leaf, giving the veins and veinlets a whitish color which shows in the cured tobacco. Hooker recommends clean cultivation of the field between crops and spraying the plants twice a week, beginning while they are in the seed beds.

The "White Fly" of tobacco (*Aleyrodes tabaci* Germadices).—One of the insects especially noticeable in Europe is a minute form which looks like a small scale insect on the under side of the leaf. The species found in the United States (*Aleyrodes vaporiarum* Westwood) has not been observed definitely in tobacco fields but because it has always been found to attack tobacco in experimental plots, it is very probable that sooner or later it will be found in the fields too. The larvæ are nearly white or yellow and are attached to the leaf like scale insects. Spraying the under surface of the leaves with soap and water (one pound in eight gallons) should be given in order to destroy those which hatch from the egg after the previous application.

Plant lice (*Nectarophora tabaci*).—Green plant-lice are occasionally found on the under side of the leaves, especially the terminal leaves, although in Connecticut they have been observed on the older leaves. These insects do little damage, however. A spray of one pound of laundry soap dissolved in eight gallons of water should kill the lice. Nicotine sulphate is more effective.

The Mealy bug (*Dactylopius citiri* Risso).—The common mealy-bug has been observed in green houses, at Washington, D. C., to thrive and multiply alarmingly upon tobacco plants. It has not been recorded thus far, however, in open fields.

The Twelve-Spotted Driabotica or "Corn root Worm" (*Driabotica 12-punctata* Fabr.).—This insect is commonly found on tobacco in Connecticut, and injures it slightly by boring small holes in the leaves. It is also observed in Kentucky. It is not a dangerous tobacco insect, however.

Slugs (*Limax campestris* Binney) *and allied species*).—Plants in seed beds and sometimes recently transplanted seedlings are occasionally damaged by slugs; here arsenical poison can easily be used.

The Tarnished plant bug (*Lygus pratensis* Linn).—This insect has been found on tobacco in Connecticut and is thought to do more or less injury. Thus far, however, nothing very definite regarding the economic importance of the insects as a tobacco pest, has been established.

The Tobacco stalk weevil or Pith worm (*Trichobaris mucorea* Lee).—This beetle tunnels in the leaf stalks and in the main stem, often going down into the root. It is closely related to the corculionid potato stalks weevil (*T. trinotata Say.*). A soon as the crop showing the presence of this pest is harvested, all the stalk and rubbish should be burned.

"Stalk borers" (*Papaipema nitela* Guen).—This is another insect which may attack tobacco. It tunnels in the pith of the stems of potatoes, tomatoes, and other garden crops. Its adult is a mouse colored moth. Evidence of the pests should prompt clean cultivation and removal and burning of old stalks.

Tenebrionid beetle (*Opatum intermidium*).—This insect is not yet found in the United States but it is considered as a true tobacco pest in Russia, attacking the stems underground.

There is still a considerable number of insects observed on tobacco in the field that are not mentioned in this chapter, but they are of so very little importance as to be hardly worthy of the growers' attention.

The cigarette beetle (*Lasioderma serricorne* Fabr.).—Stored tobacco, cigars, and cigarettes are frequently attacked by insects and injured to a greater or less extent. The chief depredator is a small bettle of the family *Ptinidae,* bearing the Latin name *L. serricorme* Fabr. This beetle breeds in tobacco and many other dried vegetable products. The adults bore their way out,

leaving small round holes. This, of course ruins cigars and cigarettes, or, if leaf tobacco is attacked, spoils it for wrapping purposes, and its value diminishes. Fumigating with carbon bisulphide, or steaming the tobacco, will destroy the insect in all its stages.

In fumigating with bisulphide, every precaution should be taken to see that the room is perfectly air-tight, and also that no fire is allowed to enter the room until it has been most thoroughly aired. The vapor of carbon bisulphide in confinement is inflammable and explosive. One ounce of the liquid should be evaporated for every 62½ cubic feet of space, or one pound for every 1,000 cubic feet.

Cellophane wrappers have contributed much recently in protecting cigars and other manufactured tobacco products from the beetle.

Of particular interest is the fact that a little four-winged fly (*Catolaceous anthonomi* Ashmead) is parasitic on the cigarette beetle, laying its eggs in the larva of the beetle. While the parasitic work of the fly is not very great, it nevertheless keeps in check the rapid multiplication of the pest.

Other beetles known occasionally to infest dried tobacco are, the drug store beetle (*Sitodrepa panicea* Linn), the leather beetle (*Dermestes vulpissus* Fabr.) and the rice weevil (*Calandra oryza* Linn). Remedies are the same as for the cigarette beetle.

TOBACCO DISEASES

Damping off (*Rrizoctonia solani, Phythophora nicotiana, Sclerotium rolfsii and Pythium debaryanum*).—Damping off is a disease in the plant beds commonly caused by four fungi of the genera *Pythium*, *Phythophthora*, *Sclerotium* and *Rhizoctonia*. The symptoms of these two diseases are identical, but upon microscopic examination the difference can be easily determined in that the mycelium of *Phythium debaryanum* is nonseptate while that of *Rhizoctonia solani* is septate. Wet soils, abundance of organic matter, high humidity and poor ventilation of seed beds, are the principal factors that favor damping off diseases. The disease can be avoided by sparse seeding and by utilizing new land for seed bed purposes. If old lands are used for seed beds they should be thoroughly sterilized. A good drainage is an essential factor that should not be overlooked. The shed of the plot beds should be removed occasionally during good weather

and the beds should be watered thoroughly but not too frequently. If only patches are infected, these spots should be scraped (seedlings and soil) and the areas sprayed with 1:50 formaldehyde solution.

Seedling stem rot.—While the general effect on the seedlings of the fungus causing seedling stem rot, is the same as damping off, the causal organism, however, is entirely different, because of the presence of white fungus threads creeping over the decayed plants. The remedies are the same as the means employed against the damping-off trouble.

Root-rot (*Thielavia basicola* (B & Br.) Zapf.).—Root-rot is another fungus disease causing rotting of seedlings in the beds and poor stand of plants in the field. This disease is limited to the root system so that symptoms above ground are marked by stunted growth and chlorotic appearance. Generally the symptoms above ground resemble those caused by food deficiency. The only way to distinguish the root rot is to examine the root system of the plants. As this disease can stay in the ground for a considerable length of time it is best to practice rotation in highly infected ground. Low soil temperature favors the occurrence of root rot. Root rot in seedbeds can be avoided by using new land for seed plots, or, if old lands are used, they should be thoroughly sterilized. The transplanting of seedlings that are infected with root rot should be avoided, and if sufficient ground is available, heavily infected ground should be fallowed for at least two or three years. The planting of resistant varieties cannot be over emphasized.

Sumatra disease (*bacterial*).—This trouble appeared on Sumatra plants in Connecticut in 1907 and caused severe injury. The disease is different from damping off troubles and root rot because the injury includes the base of the stem and the root immediately below it. It has not been seen yet on the variety Havana or Broadleaf. While the disease has not as yet been definitely identified, actual available evidences seem to show that it is bacterial. It is easily checked by breeding for resistant tobacco varieties or strains.

Canker (*bacterial*).—Canker shows as a girdling of the stem underground of a diseased area on the stem above. In the latter case there is a dark brown sunken area in the bark, sharply marked off from the healthy green bark. While other diseases or even insect injuries may be the starting point of the disease,

the canker itself is probably of bacterial origin. Till now it has not been common enough to do serious damage. Heavy manuring seems to favor the development of this disease.

Mosaic or calico.—The mosaic disease is characterized by crinkling and by the molted condition of the leaves. The diseased areas either appear lighter or dark in color than the healthy portion and are rough to the touch. The causal organism is so far not known and it has never been possible to demostrate the presence of either bacteria or fungus in the tissues of any part of the affected plant. Until more is known about the action of the so-called "ultramicroscopic" organisms, the disease cannot be ascribed to an organism of that class, as the character and reactions of the causal agent do not in any respect coincide with the reactions of that class of organisms. Many of the reactions of the causal agent are of such nature as to indicate that it is either an enzyme, an aggregate of enzymes, or the product of enzyme activities.

While the disease is not contagious, it is very infectious, particularly when inoculated into young plants. On fields, the infection can be usually traced to the seed bed. Infection is usually effected by careless handling of the seedlings during pulling and transplanting and in worming. It is estimated that about 80 per cent of infections occur in this manner.

Owing to the nature of the disease the matter of absolute prevention and control is difficult, but with careful attention to details of sterilization of the seed bed and handling of the seedlings at transplanting and worming time, a large percentage of infection can be avoided. The hands should always be washed after touching calicoed plants, and in worming separate workers or worm pickers should be assigned to pick worms only on affected plants. Mosaic or calico appears on plants of any stage, young and old alike, but the disease seems to be more ravaging when the plants are about to flower.

Frenching (nutritional deficiency).—The frenching disease is frequently confused with mosaic and at times both are considered as one and the same thing. This confusion is due to the identical symptoms exhibited by affected plants during the early stage of either disease. The early signs of the appearance of frenching is like the early stage of mosaic. It is only when the disease is approaching the severe stage that real frenching habits are manifested. Plants attacked by frenching are weak and very brittle. The leaves of plants attacked severely with french-

ing become narrow and ribbon-like. In many cases the leaf buds grown in bunches, are tooth-pick-like and stringy. The upper surface of the leaves shows yellow spots, and the leaves are thicker than normally. When this disease appears on the seed bed, the seedlings could hardly be recognized as tobacco seedlings, due to the stringy and tooth-pick-like leaves and almost without any visible internodes.

The disease may appear at any stage of the development of the plants and oftentimes occurs when the plants are at the flowering and suckering stages. This disease is not infectious and therefore, is not a germ disease but is due to malnutrition. Deficiency of nitrogen in the soil, defective drainage, wet soil and poor cultivation are the factors that may bring about the occurrence of frenching. This disease was successfully controlled in La Union Province, by the application of nitrogenous fertilizers. This disease has been the subject of intensive investigations in the United States and was found to be due to nitrogen soil deficiency. It was observed that under Isabela conditions disease seedlings when grown in rich alluvial soils grow into normal plants even without fertilizer application. The plant affected recovers because the frenched leaves do not become normal but as the plant grows the subsequent leaves develop into normal ones and when the plant has become big enough the disease is absolutely without any trace. Highly inclined grounds when not properly terraced to prevent soil washing due to heavy rain are likely to produce frenched seedlings. Old land for seed beds must be adequately fertilized and if the disease occurs among the plants in the field the application of nitrogenous fertilizer is inevitable. This disease occurs both in the shade and in the open culture.

Nematode or root knot (*Heterodera radicola*).—Root knot is caused by a minute eelworm or nematode which bores into the roots. These little worms scarcely visible to the naked eye, cause the roots to develop characteristic hypertrophies or galls varying greatly in size. This disease, therefore, is very easily recognized by examining the root system. Plants heavily affected with root galls are stunted in growth and appear chlorotic. Seedlings with root galls should not be planted and fields severely infected should either be fallowed or planted with other crops for at least two or three years before it can be planted again to tobacco.

Bacterial (Granville) and Fusarium wilt.—The causal organism of bacterial wilt is *Bacterium solanacearum* E. F. S. while that of Fusarium wilt is *Fusarium* sp. Both diseases attack the root system of tobacco and other members of the nightshade family like potatoes, tomatoes, eggplants, etc. It is hard to determine the differences between these two diseases if judgment is based only upon external appearance of affected plants because the symptoms are the same. The only way to determine whether the disease is either bacterial or fusarium is to examine the roots and stems of a diseased plant. When the stem or root system is halved longitudinally and the section upon being pressed between the fingers oozes out slimy liquid that is somewhat putrid in odor then the disease is bacterial. Otherwise the disease is fusarium. The fusarium wilt infection seems to be favored with the increase of temperature while the bacterial wilt acts more favorably when the weather is moist and cool. Early planting escapes the fusarium wilt a great deal but at the same time suffers from the bacterial wilt if both diseases are present in the same soil. It is a very unfortunate fact that in the Philippines both diseases occur in the principal wrapper tobacco regions. The bacterial wilt is severe in Laguna while the fusarium has ridden the wrapper district of La Union. Crop rotation should be a good practice, the tobacco rotated with legumes after every five to seven years. The development of resistant varieties while not an immediate remedy will in the long run be a more stable and effective method of minimizing the ravages of these diseases. It has been found after two years trial that under La Union conditions, severe fusarium wilt infection can be checked very successfully by erecting shelter tents over the plantation. This finding simply correlates the observatoin of other workers that the fusarium wilt infection increases as the temperature increases and vice versa. It may be stated here that the growing of wrapper tobacco by shading in La Union Province has come about as an expedient remedy against the fusarium wilt as in doing so the disease is not only placed under control but at the same time the resulting crop is a more valuable crop than the ordinary cigar filler which was then the regular crop of the La Union tobacco plantations. Fusarium and bacterial wilt diseases attack tobacco plants in all stages. In mild cases one or two leaves show sign of wilting and as the plant becomes exhausted it gradually wilts and dies. In severe infection the whole plant

suddenly wilts and in a couple of days dies. When only few plants are affected in a plantation, these should be pulled and burned to at least check the spread of the disease, but when the infection is very severe even this pulling and burning of dead plants do not help very materially.

Hollow stalk.—This disease is a decay of the pith of the stalk, sometimes extending out into the midrib and veins of the leaves, causing them to drop. The decay may start from the base of the stalk, or at the top of the plant through injuries produced by topping or suckering. The disease has been shown to be apparently of a bacterial nature. Johnson of the Wisconsin Experiment Station claims that a bacillus of the soft rot type has been isolated by inoculating healthy plants. As a means of controling the disease, all affected plants should be removed from the field. Persons topping or suckering may carry the disease from diseased plants to healthy ones, which under moist conditions or weather, decay rapidly.

Tobacco injury due to malnutrition or over-fertilization.—At the Massachusetts Agricultural Experiment Station, a root injury to the plants which is manifest a week after transplanting resulting in differences in growth, has been observed. Dr. G. E. Stone of the Station claimed that the trouble is due to over-fertilization, the roots (especially the tap root) having all the characteristic symptoms of fertilizer burning—that the absence of fungi is an indication of some abnormal soil condition being responsible for the trouble. The final conclusions reached were that the combined effect of the total soluble mineral constituents (water soluble salines) in the soil is responsible for the injurious effect on the growing plants rather than an accumulation of any one of the soluble elements. This assertion at least agrees with Pfeffer's statement to the effect that "the concentration of the cultural fluid is always important, for when its osmotic concentration passes a certain limit, growth becomes impossible, though no poisonous effect is exercised. While when the fluid is too dilute, or when a single essential salt is present in insufficient amount, the development of the plant is retarded."

There are two ways pointed out to remedy the injury, crop rotation (including corn) and underdrainage. In either case the idea is to reduce the concentration of water soluble salts or mineral constituents in the soil.

Sore shank.—In this disease the stalk undergoes a decay at the surface of the ground and the plant finally topples over. The

plants, as a rule make a normal growth and there may be no indications of disease until the plant suddenly withers and dies or, perhaps, falls over from the effect of wind. Generally, damage from this disease is small since only a plant here and there over the field is affected. Occasionally this disease may cause a peculiar wilting and dying of the lower leaves, perhaps only the portion of the leaf on one side of the midrib being affected. This disease is caused by a fungus which attacks the stalk of the plant at or near the surface of the ground. No definite remedy is known but rotation of crops will probably be found beneficial.

A new bacterial leaf disease of tobacco.—This disease was first observed in the Cagayan Valley and reported in 1930. It is characterized by white or opaque spots. Tobacco seedlings may become destroyed entirely or rendered useless for planting by the disease. The causal organism of the disease is a bacterium called *Phytomonas polycolor* Clara.

So far the damage by the disease have been minimized by disinfection with silver nitrate 1–1,000 for 10 to 15 minutes. This means of control serves to destroy other organisms that are seed-borne as for example those called wild fire and angular leaf spot.

Tobacco wild fire (*Bacterium tabacum* Wolf and Foster).—The disease is so named principally because it appears so quickly and spreads so rapidly as to seriously affect the leaves. The first evidence of the disease which is due to bacteria, is the appearance of characteristic circular areas. The spots develop into larger size with a border of water soaked appearance marking the margin of necrotic tissues. Finally when the spots are numerous, they fuse causing larger irregular areas of leaf tissue to become dry.

Frog-eye (*Cercospora nicotianae E & E and other fungi*).—This leaf-spot disease appears circular, and brown with a darker order and with grayish centers as compared with wildfire spots. Upon the gray centers may be seen the fructifications of *Cercospora nicotianae* or other fungi thus far undetermined.

Specks.—Specks may be tan-colored or whitish. The whitish speck may be mainly due to a fungus (*Macrosporium tabacinum*). Specks resulting from a deficiency of potash, appear as tan colored, irregular areas which are first present at a distance from the principal veins. When this disease is accom-

panied by chlorosis there is no definite hole around the region. In the case of frog-eye and specks the margin of the affected tissues does not disintegrate and fall out as with wildfire.

Green-leaf spot.—The green spot disease of tobacco is a serious handicap in the production of wrapper tobacco. Considerable attention was attracted by its prevalence in Sarunayan, Cotabato in 1927. Since then it has remained a serious problem. The harvests from this region were rejected by cigar manufacturers because of the presence of the green spots. The disease renders the crop unfit for wrapping high grade cigars.

From an investigation of the disease conducted since the early part of last year, it appears that the disease may be controlled by treating the leaves with 5–10 per cent solutions of Acetic acid. With this treatment the green spots disappear from cured leaves without any apparent injury to the quality of the wrappers. Other very beneficial effects derived from the treatment are the retention of the desirable texture, pliability, color of the leaves and the prevention of the active growth of molds frequently encountered on tobacco leaves. Treated leaves under observation for nearly a year now, have not shown any untoward effects upon the quality. Other treatments used did not give as good results, and some gave entirely negative results.

From the studies on the possible causes of the disease, a fungus very similar to *Botrytis* was isolated from the green spots. Artificial inoculations on potted plants and harvested leaves reproduced the disease typically and readily on the latter under very moist conditions, while on the former, two kinds of spots, brown and green were produced.

The green-leaf spot is apparently influenced by altered weather factors brought about by shading. Laboratory tests confirmed the presence of abundant green pigment and starch in the spot. This spot malady is never noticeable in the field and therefore is very deceiving. It begins to manifest itself when the leaves begin to cure, the spots drying very much faster than the remaining portion of the leaf. Open grown wrapper is seldom affected by the green spot. As its name indicates, the spot is deep green in color on cured leaf, very brittle, and feels rough to the touch. The spot, however, becomes lighter in color in fermented leaves. This green spot malady can possibly be gotten rid off in the field by using thinner shade and by erecting shelter tent higher than six feet in order to give more air to the shaded plants.

In general the factors concerned in bringing about the outbreaks of leaf-spot diseases are weather conditions, maturity of leaf upon harvest, and soil fertility. Under exceptional conditions the diseases may appear at any stage from the seed beds till after the tobacco has been placed in the curing barn, but ordinarily the plant is only seriously attacked when the leaf is almost, if not quite, ripe. Again, leaf spot is never serious except as a result of wet weather. Dark shipping tobacco grown on heavy soils and topped lower is more susceptible to spotting than tobacco grown on lighter soils and topped higher. Potash in the fertilizer is of some value in reducing injury from leaf spot, but cannot be relied upon for this purpose unless supplemented by other measures; namely, the avoidance of too much ammonia in the soil or in the fertilizer and making sure that the tobacco is not topped too low. These are the only practicable measures now available for reducing the danger from leaf-spot diseases.

Orobanche ramosa L., *a parasitic plant.*—This is a flowering plant suspected in Cuba to be parasitic on the roots of tobacco. It usually stands close to the tobacco stumps, or it may be at a distance of two to three decimeters. It is generally a cluster of stalks, one to four decimeters tall, without leaves, yellowish white in color, and bearing flowers and seed pods which somewhat resemble those of tobacco. The roots of the parasite form a thick cluster and attach themselves closely to the small roots of tobacco. In Cuba, wherever the parasite occurs, it is pulled and burned.

Lightning injury.—Lightning may also injure tobacco as reported in the 1915 Report of the Connecticut Agricultural Experiment Station (New Haven). An injured plant will have one leaf shrivel up and soon another on the same side of the plant, then the whole top will wilt and die. A patch as big as one rod in diameter may be affected. Injuries, if they occur, usually follow a thunderstorm and is especially distinguished from other injuries by the fact that the affectation does not spread.

Frost fungus.—This disease appears on the leaf stems in the barn, at first in pure white patches looking like hoar frost or velvet. The patches spread to the leaf veins, destroy the tissues and decay follows. The white patches are the fruiting stage of the fungus. Its spores are developed and carried over to the next year in the stalks and waste leaves left in the barn. This mold may be prevented by perfect cleanliness in the barn from

which all stalks and waste should at once be removed. In extreme cases the floor should be covered with fresh earth or sprinkled with a mixture of slaked lime and sulphur, or the barn fumigated.

Stem rot and pole burn.—These troubles are caused principally by the growth of a fungus on the leaf in the curing barn. The fungus by destroying the tissue gives access to bacteria which induce decay. In Wisconsin, however, where the occurrence of the trouble prevails, it is credited mainly to fungi of a saprophytic nature (a species of Fusarium being the most common cause). The difference between shed burn and stem rot appears to be primarily one of location, rather than a difference in the causal organism. If the fungi attack the midrib the result is stem rot, and if the leaf tissue is attacked, the decay is called shed or pole burn. In controlling the disease, growers must rely upon regulation of temperature and humidity of the curing shed by proper ventilation, or the application of artificial heat. More than 80 per cent relative humidity in the curing barn is the danger signal while beginning at 85 per cent, the barn must be heated.

Black spot or Black rot.—This warehouse trouble appears in the leaves after these have been packed in cases for fermentation. Canker is apparently a fungus trouble in which dark colored patches are produced that often extend down through the leaves of several overlapping bands. The injured tissues are dark colored, become brittle and easily fall to pieces. Microscopic examination reveals the presence of abundant but isolated purplish black spores, apparently those of *Sterimatocystis niger.* It is not known just what conditions favor the development of this trouble, whose presence is not known until the cases are opened for examination. Probably too much moisture favors its development, especially if care has not been used in selecting and packing the tobacco.

Mold of cigars (*Must*).—Must is a fungus or bacterial trouble also developed in the packed tobacco and is named from its musty odor. Examinations of specimens show the presence of a slight whitish growth, especially along the midribs. Numerous bacteria and also some molds are found in these growths. Cultures from a specimen placed in a damp chamber produced a reddish brown mold. Dealers sometimes renovate musty tobacco by washing the leaves with rum and by sterilization with steam. Musty cigars and cigarettes are also minimized by the use of

disinfectants in pastes and the employment of tragacanth gum exclusively.

The most common species of molds found in cigars is *Aspergillus candidus*. *Penicillium glaucum* is also prevalent.

IX. CIGAR MANUFACTURE AND UTILIZATION OF WRAPPERS

Cigars are either rolled by hands or by machine. The manufacture of cigars by machinery is now carried on extensively in the United States and in other countries. In the Philippines, the dainty fingers of the Filipina women perform with concise accuracy the work of the cigar machine. As to which of these methods is more convenient and profitable depends upon existing local conditions. While the cigar-rolling machines are profitable in America and in some European countries, this is not the case in the Philippines, and the rolling of cigars by human hands still continues to be the sole method of cigar manufacture.

Manipulation and handling of leaf tobacco preparatory to cigar manufacture.—As stated in a previous chapter, there are three distinct products of tobacco for cigar manufacture: namely; the filler, the binder, and the wrapper. The filler constitutes the main body of the cigar; the binder holds the filler bunch and keeps it in shape before it is finally enveloped by or rolled into the wrapper leaf.

As a general rule, cigar leaf tobacco (filler, binder, wrapper) must first be completely and properly fermented and aged for a period of at least two years before it can be utilized for cigar manufacture. As a matter of fact, the wholesomeness of a cigar depends upon the length of time the materials are aged; the older the materials the better is the quality of the cigar.

Let us assume that a factory is to start work on cigar manufacturing. The bales of tobacco are opened and the blending according to the factory's secret formula is effected. It may be one-to-one Cuban-Connecticut blend; it may be one-one-to-one Cagayan-Isabela-La Union blend; it may be one-to-two Partidos-Vuelta Abajo blend; etc. The leaf tobacco is then subjected to steam sterilization in a vacuum sterilization machine for a period of at least 24 hours to kill all possible organisms that are likely to destroy the finished cigars. After sterilization, the leaves are plunged into a tank of water to be washed and the excess of moisture is drained off. When the tobacco is in the proper degree of pliability it is conveyed to the stripping room where the midribs are removed. In the case of fillers and bind-

ers, the midribs are removed by hand, while wrappers are stripped either by the stripping and booking machines or by hand. The stripped tobacco is next scattered about on a spacious floor or on racks to effect further drying until it is in good order, after which the materials are piled in heaps to complete the fermentation. Fermentation usually takes place in 40 to 60 days, the pile being destroyed and rebuilt regularly to effect an even and thorough fermentation. In cases where the tobacco is an unusually old crop, this fermentation process is generally omitted. The crop is then ready for cigar manufacture.

CIGAR MANUFACTURE AND HAND ROLLING

The cigar maker sits in front of a table that is provided with a trough for waste and a rack for holding the rolled cigars. He is provided with a flat knife for cutting the wrapper to the required shape and size and for evening the length of the cigars. On one side of the table are bunches of filler and binder piled separately and on the other side is the pad or book of wrappers covered with a damp cloth. Just in front of him is a rectangular piece of hard wood on which he rolls the cigar, and besides this wood is a cup of gum tragacanth, usually of the same color as that of the wrapper leaf, for pasting the tip of the cigar. As a rule, only one size and shape of cigar is assigned to each cigar roller. In this way every individual worker becomes expert in the rolling of a specific shape of cigars.

The workman takes a sufficient quantity of filler, arranges it longitudinally, binds it with the binder leaf to form the required shape, and winds the wrapper that has already been cut and trimmed spirally around the cigars beginning at the tuck end. The wrapper is secured either by pasting the entire wrapper blade or by simply gluing the blunt end of the cigar. High grade cigars have only their blunt point pasted, while cheap cigars and cheroots generally have their wrappers pasted throughout the length of the cigar. The cigar is then smoothed to roundness by the flat knife as a finishing touch and afterwards placed on the rack. Cigar rollers become so expert that the size, body, shape, length, and evenness of the cigars are always uniform. As the finished cigars accumulate, they are bundled by 50's or 100's and turned over to a foreman. A Filipino cigar maker can roll as many as 150 to 400 cigars a day, depending upon the size, shape, and style of the brand assigned to him. Both men and women are employed in cigar making.

Classification and sorting of cigar.—The foreman of the cigar rollers delivers the bundled cigars to the man in charge of the sorting and classification rooms or "escogidas" where the cigars are sorted and classified according to color, size, shape, and finish. All cigars not coming up to the standard are separated and discarded. Cigar sorting is therefore mainly dependent upon the wrapper.

Sterilization of cigars.—The cigars, after thorough sorting and classification, are next brought to the vacuum chamber, packed in temporary boxes, and subjected to high heat to make sure that any remaining organisms or insects destructive to the cigars are killed. This treatment lasts for 24 hours, after which the cigars are conveyed to the banding and boxing or packing rooms.

Banding, wrapping, and packing of cigars.—Most brands, before they are incased, are banded with beautiful paper rings bearing the name of shape, brand and the factory, and wrapped singly or collectively with tissue paper, tin foil or cellophane (now universally used because of its transparency and durability). This done, the cigars are packed into fine cigar boxes made of wood, metal, or pasteboard. The number of cigars in a box varies from 10 to as many as 500 or even 1,000. The packing of cigars by the hundreds in expensive cigar cabinets and other fancy containers is done only for orders coming from high personages, like kings, emperors, princes, statesmen, etc. Expensive cigars for retail are as a rule packed in small quantities, generally not more than 50 in a box. The more common number, however, is 25 cigars to a box. In rare cases, a one-peso or one-dollar cigar is packed singly. The boxes are nailed and sealed at the edges with fancy strips of paper or cloth, labeled, branded, and stamped—ready for immediate shipment to retail jobber or for storage.

CIGAR MANUFACTURE BY MACHINERY

Automatic machines for the manufacture of cigars have been perfected during the last ten years, and these inventions led to a revolution of the cigar manufacturing industry in the United States and other countries. About fifteen years ago, cigar machines made their appearance that, in a single series of uninterrupted operations, weigh and bunch the filler, roll it on the binder, and deliver the bunch to a wrapping station where the cigar is finally wrapped with the wrapper leaf, then convey

it automatically to the inspection table as a complete cigar. In fact, all operations from blending, steaming, washing, drying to banding, packing, or boxing are done mechanically. There are various makes of cigar-making machines on the market, but the principles or mechanism of their operations are practically the same. A modern machine has an output of 20,000 to 30,000 cigars weekly. These machines are designed to make cigars of any size and shape, and to use any kind of leaf tobaccó as materials. A cutting station weighs, measures, and feeds the required filler to form the bunch, transfers it to a rolling belt where it is wrapped by the binder, thus forming the bunch. The bunch is next rolled, softened, and crimped through a series of belts, girding plates, and gears, after which it is conveyed to the wrapping, re-rolling, and trimming divisions. The finished cigars proceed next to the sorting and classification divisions where they are sorted and classified as to color and size by an automatic cigar sorting machine operated by electricity. The so-called "eye" of the machine is a photo-electric cell similar to that used by astronomers in determining the intensity of the light of stars. This cell generates electricity proportional to the intensity of light that strikes it. Cigars of light color reflect more light than cigars of darker color. The cigars, having been sorted and classified, are next transported to the banding and packing machines where they are banded and packed into cigar wooden boxes, metal cases, or card-board containers. Cigar boxes and other containers are also made by machines. Even the branding and stamping of the boxes are mechanical operations. Among the important machineries employed in cigar manufacture are the stripping and booking machines, the bunch-making and the cleaning machines, the stamping machines, the cellophane wrapping machines, the banding and packing machines, and the cigar-box-making machines.

COLOR, SHAPES, BRANDS, AND BOXES OF CIGARS

Commercially the colors of cigars are designted as *claro* (very light brown), *colorado claro* (light brown) *colorado* (brown), *colorado maduro* (dark brown), and *maduro* (dark). When the *maduro* color was still very popular, the *oscuro* (black) was also a standard color. In sorting and classifying the finished cigars, however, the manufacturer distinguishes as many as 100 shades of the above five standard colors. This phase of the work, of separating all shades of a single color, is very important, because

it renders possible a uniformity of color of the cigars in a box, thereby satisfying the whims of the most critical smoker. The only colors, however, used as trade marks on cigar boxes are the five colors mentioned above; these alone are known to the public and recognized by smokers. The rôle of wrappers is obvious as regards cigar colors.

The nomenclature of the numerous shapes and brands of cigars is very extensive and several factories name some of their products after famous men of history, famous places, and even deceased managers of their firms. Invariably the name of the factory is the main brand. Among the popular shapes of the present are the *Presidentes, Vice Presidentes, Excelentes, Especiales, Conchas, Perlas, Perfectos, Divinos, Imperiales, Incomparables, Esmeraldas, Predilectos, Londres, Invincibles, Coronas, Brevas, Damas, Panatelas* and *Regalias*. Each brand as a rule includes several sizes, shapes, and colors. Fashion is full of vanity, so that in spite of the ceaseless attempts of manufacturers to standardize the shape, size, and color of their products, they can not do so because of the ever changing whims of smokers. There was a time when big black cigars were in demand. Soon after, the speckled type became so popular that some factories went to the extent of artificially causing spots on the wrapper. Later on *oscuros* were in great demand. The call for the present-day light *claro* cigar has been of fairly recent date. As to what type and color of cigars will be desired in the near future, only time can tell.

The kinds of wood generally used for cigar boxes are Spanish cedar (*Cedirela odorata*), Philippine Calantas (*Toona calantas*), Rosewood, and Mahogany. These are peculiarly adapted for cigar boxes because of their lasting aroma, which, when blended with the aroma of cigars, makes a pleasant wholesome combination, improving the quality of the cigar. Other cigar boxes are made of glass, fancy porcelain, and lithographed metals. Very low grade cigars are packed in card board packages or boxes. Cigar cabinets made of the finest wood are sometimes inlaid with jewels and enamels of great value. These splendid specimens of art have found their way into the art stores of Europe, commanding considerable prices.

X. TOBACCO BREEDING WITH SPECIAL REFERENCE TO WRAPPER PRODUCTION

The tobacco of commerce is known botanically as *Nicotiana tabacum* L. It was named after Jean Nicot who introduced the

plant into Europe from Portugal. There are approximately about 50 species of *Nicotiana,* some of which are subdivided into varieties. The tobacco of commerce (*N. tabacum,* Linn.) is a tall herbacieous annual plant reaching a height of from 1 to 3 meters. The leaves are lanceolate to elliptic-ovate, acuminate-pointed, sessile or petiolate and decurrent, and usually pubescent. The flowers are about 2 inches long, from almost white to pink, forming a large terminal and compound panicle. The calyx is green, 1 to 1.5 cm. long, enlarged in fruit. The corolla is narrow, funnel shaped, 5-lobed and about 5 cm. long. The capsule is 2-celled, ovoid, 1.5-2 cm. long with numerous small seeds. From earliest times the Indians in America cultivated it.

Strictly speaking, there are only four recognized wrapper tobacco varieties; namely, the *Sumatra, Cuban* (*Havanensis*), *Havana seedleaf* and the *Connecticut broadleaf.* To these can be added the Porto Rican and Philippine wrapper varieties: Simmaba, Vizcaya, and Ilagan Sumatra. These varieties have been fully described previously.

Varietal classification, especially with reference to wrapper and other cigar tobacco varieties, are based mainly on noticeable leaf differences and climatic and soil adaptations. There is no crop more susceptible to variation and deterioration than tobacco. The various types and varieties of tobacco now in existence are the result of continuous selection, hybridization and adaptation to meet the demands of manfucturers and consumers. This work for the preservation of existing good varieties, as well as the creation of new ones, is an endless task and requires the services of patient and tireless researchers.

INBREEDING

The properties of ideal wrapper tobacco have already been defined repeatedly in the preceding chapters. Before discussing the feasible methods whereby these ideals may be obtained, it is necessary to dwell for a moment upon the importance of inbreeding with reference to tobacco in general.

Tobacco plants are characteristic or typical examples of certain groups among the higher plants which are distinguished by more or less insured continuous self-fertilization. It is because of this fact that species and varieties of *Nicotiana* were used to advantage by investigators of sexuality and inheritance in plants even as early as 1776. Among the early investigators who worked on members of the genus *Nicotiana* are included

practically all the famous forerunners of the science now known as Genetics.

Starting with the universal saying that "like begets life," it is readily observable how important inbreeding must be. Experience has shown conclusively that seed from inbred or self-fertilized tobacco plants tends, if not altogether definitely, to produce a uniform progeny. Experience and experiments have also shown that seeds produced by self-fertilized tobacco plants are just as viable or as strong, if not stronger, than cross-bred seeds. However, as a result of the activities of flying insects going from one tobacco flower to another and from field to field, and possibly also through the agency of the wind, foreign pollen often find its way to desirable mother plants. It is advisable, therefore, to resort to a means whereby self-fertilization is absolutely insured. The flowers must be bagged. Bagging is a simple operation. Patented paraffine or manila paper bags may be used. Too heavy a covering would bend the flower cluster to an unnatural position, adversely affecting the development of the seed. For this reason, it is well to place a strong stake close beside the plant and to tie the paper bag to this. In humid regions cheese-cloth bags are preferable as they can stand being wet better than paper.

From 12 to 15 days after the pods are formed, the bags can be removed and the seed allowed to develop and mature in the open; care should be taken that all the young buds are pruned, to make sure that only self-fertilized seed is obtained. When the seed pods show signs of maturity, the flower clusters should be cut off and hung up to dry for some time in a well protected place, preferably in a curing shed where there is no chance of their getting wet; when thoroughly dry, the seed should be threshed, cleaned, and stored in air-tight bottles or jars with a few tablespoonfuls of flaked naphthalene to protect it from seed-eating insects.

Detail study of the tobacco flower.—For a better realization of the case with which tobacco plants are self-fertilized and of the possibility of cross-fertilization, the following study on the structure and arrangement of tobacco flowers from "Tobacco Breeding" by Shamel and Cobey, U. S. Department of Agriculture, Plant Industry Bulletin 96, is hereby given:

The tobacco flowers are arranged upon a branching determinate flower head, which appears when the middle leaves are about half grown and continue to develop and produce new flowers during the rest of the life of the plant. Fig. 6 is a sketch of a longitudinal cross section of a tobacco

flower, showing the parts of the flower and the general way in which pollination takes place. The calyx (A) is the outer green five-parted, floral envelope at the base of the flower which serves to protect the flower bud. The corolla (B) is the delicately colored floral envelope inclosing the reproductive organs of the flower. Its color tends to attract insects, which are the principal agents in cross pollination. Next inside the corolla are the five staments which are the male reproductive organs of the flower. Each stamen consists of the filament (I) supporting the anther (J) in which the pollen grains (K) are produced. The central organ is the pistil, or female part of the flower. The terminal enlarged portion (G) is the stigma. The pollen grains (K) adhere to the surface of the sigma and germinate, sending an extremely minute tube (E) down through the central conductive tissue (H) of the style (F). This tube extends into the cavity of the ovary (D) and finds its way into the ovule (N) through a small duct or micropyle (M) where fertilization takes place. Other ovules are fertilized by other pollen tubes. These ovules develop into seeds after fertilization. The ovary is two-celled with a fleshy central placenta (C) on which the ovules are borne. The early capsules mature always before flowering ceases. The shape of the delicately colored corrola is somewhat tubular, or, perhaps, more nearly like an elongated funnel. It is comparatively small from the basal end to a point about two-thirds the distance to the terminal end of the flower. At this point it enlarges suddenly to more than twice the size of the basal part of the tube. It is composed of five petals, which coalesce to form the corolla tube and separate only at the extreme end. The tobacco flower is symmetrical. The number of sepals and stamens is always the same as the number of petals, but the floral circles do not remain constant, varying rather indefinitely in different strains and even among individuals of the same strain. Trimerous flowers or flowers with three parts in each flower circle, have been found growing in the same plants with pentamerous flowers or those having five floral parts. This is the exception, however, and not the rule.

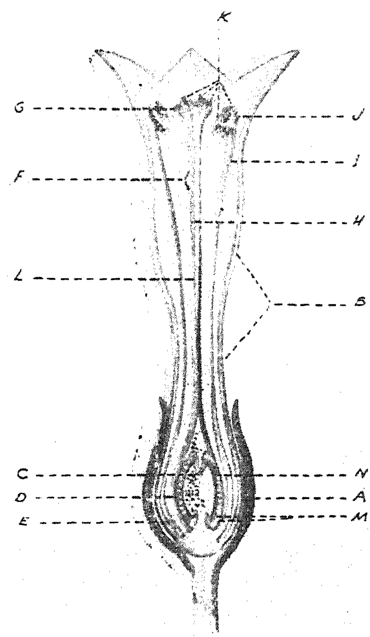

FIG. 6. Diagram of a tobacco flower (longitudinal section).

A very interesting phenomenon occurs in the filaments of the stamens immediately after the opening of the flower. Just before the opening the pistil is longer and extends up beyond the stamens, but when the anthers open and the stigma becomes receptive, a very rapid growth of the fila-

ments takes place, which causes the open pollen sacks to be pushed up past the stigma, and in almost all cases they come in direct contact with the stigma in passing upward. This gives an opportunity for at least a portion of the pollen grains to adhere to the viscous surface of the stigma for self-fertilization to take place as already described. It is just before this process occurs or while it is in progress that there is danger of, and opportunity for, cross-pollination. The open flower contains a small drop of nectar at the base of the corrola tube which is sought by honey bees, bumblebees, and humming birds as well as by many species of minute insects, all of which carry pollen from flower to flower and from plant to plant in their constant search for the honey-like substance secreted in the corrola tube. In passing in and out of the flowers the bodies of the bees and other insects and the beaks of the humming birds become dusted with pollen, which is transported by them to the pistil of the next flower visited. The ovules are readily fertilized by pollen from the surrounding plants as by the pollen from the flower in which they are produced. This continuous crossing necessarily results in the introduction and intermixture of poor and undesirable varieties in our best strains of tobacco.

Variation.—For a better understanding of the primary importance of selection in the production of wrapper tobacco, it should be made plain that under ordinary conditions, tobacco everywhere, while it admits of easy inbreeding, is a variable plant. If one should study the variability of a field of wrapper, he will observe at least the following characters in greater or lesser variation.

1. Height
2. Number of leaves
   - (*a*) Number of sand leaves
   - (*b*) Number of standard leaves
   - (*c*) Number of top leaves
3. Dimensions of leaves and character of petiole
   - (*a*) First lowest standard
   - (*b*) Last upper standard
4. Form or shape of middle standard
5. Texture
   - (*a*) Pubescence
   - (*b*) Gumminess
6. Color of leaf
   - (*a*) Dark green
   - (*b*) Green
   - (*c*) Light green
7. Charactter of leaf surface
   - (*a*) Hairy
   - (*b*) Smooth or oily
   - (*c*) Wavey

8. Position of leaf on stem
   (*a*) Horizonal
   (*b*) Erect
   (*c*) Drooping
9. Length of internodes
10. Branching habits
11. Flowering habits—cluster form
12. Possibly disease resistance

In recording the number of the leaves per plant one or two dead bottom leaves must be discarded. The sand leaves are first counted; they number from 3 to 5. The size of the sand leaves is greater than that of the top leaves.

From the fifth leaf, depending upon the age of the plant, the standard leaves are counted. These are the most valuable leaves and they vary in number. The last standard must not be less than 30 centimeters in length. So all leaves less than 30 centimeters or 11 inches are considered and counted as top leaves.

The dimension of the leaf is determined by measurements of the length and width. The length is measured from the base of the petiole to the tip, depending upon whether the petiole is winged or not. The width is measured at the broadest part of the leaf.

The best way to determine the shape of an average standard is by an accurate sketch or drawing of the leaf. If possible, it is better still to take a photograph.

To determine the texture of the leaves, press the leaf's lamina between the thumb and middle finger. Another way is to use a hand lens. The degree of gumminess is determined by the abundance of gum glands in the form of brownish knobs at the end of the hairs. The hairs occur on both surfaces of the leaves. Heavy rains, however, may reduce gumminess.

Correct sight is necessary in judging the color of the leaf in spite of the fact that it is easy to distinguish green, dark green, or light green. Color, as a rule, determines type because it varies under the same treatment and conditions.

The character of the leaf surface is easy to note. Again the hand lens is very necessary to determine the nature of pubescence, whether coarse or fine. Oily and smooth leaves go together. Some plants have their leaves dry or rough in appearance.

The position of the leaves may be shown by sketches or merely by stating whether they are erect, horizontal, or drooping, with a full understanding of the meaning of each term. The length of the internode is better determined after all the leaves are harvested. Variation in length of internode is determined by measuring the fifteenth internode.

The branching habit is determined by the tendency of certain plants to produce more suckers than others. Flower heads or clusters are judged by their size, uprightness, branching habit, and shape.

In selecting mother plants, in addition to the desirable qualities of the ideal Sumatra leaf already described, the following points should be given special consideration:

1. The leaf should be as round as possible. Round leaves give more wrappers than narrower leaves, other things being equal.

2. The position of the leaf on the stem should be as horizontal as possible. Horizontal leaves intershade better, insuring finer leaves when the plants are closely planted.

3. The shorter the internodes the greater is the number of leaves produced per unit of length. The greater the number of suckers, the less the number of leaves there will be, or the size of each leaf will be reduced. This may be due to the fact that the plant cannot feed all its parts equally so that any abnormal growth of certain parts causes the other parts to suffer. Plants with long internodes as well as plants having vigorous sucker growth, therefore, should be avoided.

4. The plants should have strong, upright, and symmetrically formed flower clusters or heads. The reasons are obvious.

5. In theory thus far light colored flowers are supposed to be correlated with light colored cured leaves.

Method of selection.—How to go about saving and caring for the seed of selected parent plants has already been explained. Because tobacco is grown in a heterogenous field, it follows that, although uniform plants may be selected for seed, the progeny from the collectively sown seed may often be quite diverse. Thre are so many characters involved, some of them invisible or latent, that in the breaking of types in subsequent generations, the extent of variation is hardly reduced. The safest and surest method, therefore, is to grow the inbred seed of each parent plant in the same plot or row. In the second generation considerable variation may still be apparent but beginning with the third generation by discarding all individuals not answering to

the ideal type and growing only the seed of those plants identical with or nearest to the ideal, one may well be assured of the uniformity of the fourth generation. Through continuous discarding of undesirable individuals and the preservation of the desirable ones by pure line cultures, the time finally comes when the highest possible degree of uniformity is manifested in a field.

Monstrosities.—Every grower is perhaps aware of so-called monstrosities or teratological occurrences in tobacco fields in the form of pitcher-like leaves, fasciated stems, etc. Various theories have been advanced to explain the causes of such occurrences as environmental, physiological, etc. But the fact that monstrosities have been definitely proven to reoccur frequently from the propagation of self-fertilized seeds of monstrous plants, indicate that such plants should be discarded absolutely. The inconveniences resulting from such occurrences are obvious.

Records.—Permanent records are essential for a better understanding of the immediate problems of the grower or breeder. Having the figures and data always on hand, one can better appreciate what is wrong with the seed or where improvement has been definitely attained. In selection as well as in hybridization, it is necessary that an accurate description of all plants in pedigree cultures be given with the most painstaking care. A good method of recording description is by following the list presented in connection with the study of variation. To this list, however, must be added the following:

Yield per acre or hectare.
Quality of cured leaf.
Quality of fermented leaf.

The opinion and the advice of cigar manufacturers or experts should be sought as a guide in determining and improving the last two properties.

Environmental considerations.—While it is an admitted fact that environment may affect the tobacco plant in growth and in composition, it cannot be a source of medium in the production of new types as claimed by certain writers. Lately sufficient evidence has been presented dispelling all possible faith in this belief. The experiments of Hasselbring and Hayes proved conclusively that crossing is the only means of producing new types. Hasselbring grew seed of tobacco from pure lines both in Cuba

and in Michigan, and found that there was no breaking up in types due to changes in environment.

Hayes noted that whatever changes take place affect all individuals of a strain in a similar manner. Hayes, after growing Cuban tobacco in pure culture, grew seed of the same in three different and distinct environments (1) in a poor gravelly loam which was manured and fertilized with chemicals, in New Haven, Connecticut; (2) in a very good and heavily fertilized inland soil at Bloomfield, Connecticut; and (3) in a seashore fertile soil at Forest Hills, Massachusetts. He found that the crops in the three places were uniform with an average mean variation of 1.8 per plant. The writers in 1916 observed that Sumatra tobacco may be grown in the Philippines without any appreciable departure from the general distinguishing characteristics of the original Sumatra type in spite of the fact that Sumatra is very near the Equator while the Philippines are much farther north.

HYBRIDIZATION

An account of the floral structure and seed development of tobacco has already been given. Strictly speaking, hybridization is the crossing of any two plants different from each other in at least one heritable character, whether they are of the same or of different variety or species. Plants are hybridized to increase their variability, thus affording more material on which to practice selection. In order to understand the rôle of hybridization in plant breeding, however, one must be acquainted with some of the underlying principles attending the problem.

In the first place, the parent plants should produce true-to-type seed after at least two to five seasons of testing, because, as will be later explained in the light of modern Mendelian studies, seed behaving with variability is actually of hybrid origin. When hybrids are crossed, matters only become worse through confusing complications.

The technique of hybridization of tobacco.—To begin with, it does not make any material difference which variety is used as the male and which as the female parent. The plant to be used as the female parent should be emasculated and prevented from setting seed fertilized by its own pollen; this should be performed before the anthers have matured. The pollen of the male plant should be applied to the stigma of the female plant when this is in a receptive condition. To prevent the intru-

sion of foreign pollen, the flowers should be bagged in the manner as for self-fertilization or inbreeding.

It appears that in tobacco, the later flowers produce larger and healthier seed than the earliest ones; this fact might well be given consideration in hybridizing. The best time for emasculation is when the flowers are apparently fully developed but the corollas still closed. In order to insure protection to the pistil, the corolla and the calyx should not be cut off as is the general practice. Artificial pollination is just as conveniently done by merely slitting the corolla at one place and piercing it at two points vertically at the middle with an ordinary pin to keep it well-open. With small scissors the anthers are easily removed. Sometimes as a means of further precaution, the stigma is washed with a dental syringe before pollinating it. The pollen should be applied with a smooth-surfaced pointed instrument like a scalpel which can be easily washed in order to be sure that only pollen of pure origin is used. Because a large number of seeds is produced in a single pod (from 3,000 to 5,000 seeds), it is not necessary to pollinate a great many flowers. All non-crossed pollinated flowers should be carefully cut out with small slender scissors.

Inheritance in plants.—It has been demonstrated by experiments in sexuality and inheritance in plants that the different plant varieties, although we designate them as such, are not wholly so homogenous and so uniform as "pure lines." When we visit a field of tobacco exhibiting variability in a greater or lesser degree, our common sense would lead us to pick the most desirable individual plants for seed. It has already been made clear, how, by insured inbreeding, we can better expect the preservation of the desirable characteristics.

Modern biologists have given the term "character" to any one of the many details of structure, form, substance, or function, which make up an individual. For example, in tobacco, we speak of the leaf size, leaf grain, branching habit, etc., as characters. The transmission of the characters of parent plants to their progeny or offspring depends on free heritable elements known as factors. In the modern science of genetics, which seeks to account for resemblances and differences exhibited among organisms related by descent, factors are expressed in ortographical symbols which are worked out mathematically in much the same manner as chemical symbols, formulae, equations,

etc. Examples of this notation will be found in the succeeding paragraphs.

This factorial systematic interpretation of inheritance is based largely upon the experiments of Gregor Mendel, discoverer of the laws of heredity. Working with garden peas, he conducted investigations on the inheritance of certain definite characters. He began his work by testing varieties of garden peas exhibiting opposite pairs of characters for two or more reasons to be sure that each variety possessed the ability of reproducing itself absolutely true from the seed. Mendel studied at least seven opposing pairs of unit characters, but for the present, by way of an illustration, only one pair will be discussed. He crossed tall and dwarf peas and found that the hybrids or the first (F^1) generation consisted only of tall plants like the tall parent. He called the tall variety the dominant type. In the second (F^2) generation by selfing the hybrids, he found that these characters split up (segregated) in a more or less uniform and definite ratio—three-fourths of the plants were tall and one-fourth was dwarf. The dwarf was then designated as recessive to the tall. In the subsequent generation (F^3), by selfing the progenies the dwarf plants produced only dwarfs, while one-third of the tall plants bred true and the other two-thirds produced both tall and dwarf plants in the same proportion as the second (F^2) generation. The numeral ratio of 1:2:1 for the F^2 generation may therefore be established.

For the sake of simplification, the factor for tallness may be repesented by "T" and the factor for the opposite character, "t". The small "t" is used for the latter because it does not find expression in the hybrid. The numerical values of the hybrids may therefore be algebraically expressed thus: TT/2Tt/tt. The resultant fusion of the gametes of both sexes is known as a "zygote".

When the fusing or uniting gametes possess the same characters, the resulting zygote is said to be a "homozygote" and its constitution, "homozygous". Pure strains of plants are, therefore, homozygous. According to these definitions, when the dwarf plants are selfed, they produce only dwarf (homozygous) progeny. On the other hand when the dwarf and tall plants are crossed the hybrids do not produce only tall plants. This is explained by the fact that the uniting gametes are unlike in constitution or character. The resulting zygote from unlike gametes is called "heterozygote" and theoretically each ovule and

pollen grain would contain both the T and t characters, combining in about equal proportions as follows:

Ovules		Pollen	
T(T)		T(T)	.... TT/2Tt/tt
t(t)	x	t(t()	

When plants having two pairs of differentiating characters were investigated by Mendel, he found that each pair of characters followed the same rule and that the inheritance of each pair was absolutely independent of the other. He crossed a tall plant bearing colored flowers with a dwarf plant bearing white flowers, the resulting F_1 hybrid (first generation) being a tall plant with colored flowers. We have a case or dominance again, that of colored over white flowers. In the F_2 generation there were plants with colored flowers and plants with white flowers in the proportion of 3:1, likewise tall plants and dwarf plants. Consequently, the chances of a tall plant having colored flowers were three times as great as its chance of having white flowers. This cross resulted, as a matter of fact, in four kinds of flowers; namely, (1) colored talls, (2) white talls, (3) colored dwarfs and (4) white dwarfs, in the ratio of 9:3:3:1, respectively. As in the case of the monohybrid, this can also be expressed as follows (T standing for tallness: t, for dwarfness; C, for colored; and c, for white flowers):

1 TTCC Tall colored
2 TtCC Tall colored
1 TTcc Tall white
2 TtCC Tall colored
4 TtCc Tall colored
2 Ttcc Tall white
1 ttCC Dwarf colored
2 ttCc Dwarf colored
1 ttcc Dwarf white

If we wish to produce a homozygous tall white, all we have to do is to select plants answering to the description of three-sixteenths of all the F_3 generation, namely, TTcc and Ttcc. From previous definition, we known that in order that a plant or strain be homozygous for tall-white it must have the formula TTcc. The only thing to do is to grow all tall-whites, preferably in head to the row cultures. The rows producing only 100 per cent tall-white plants show the pure strains resulting from the origi-

nal crossing or hybridization. The Ttcc, while all have white flowers, will split into talls and dwarfs in the ratio of 3:1, as already explained.

Mendel further pointed out that the principle may be extended indefinitely. To summarize Mendel's experiments: In crossing individuals, differing in a number of opposite characters (provided the parent plants are pure strains), the first generation of hybrids has the same appearance or form; the second generation shows a redistribution of the various characters, subject to the same rule for each character; and if the constitution of the parent is known, the number of possible forms may be calculated.

Some cases of inheritance are not based on dominance. In fact, various logical explanations have been advanced for all kinds of resulting ratios other than 3:1. We shall, however, refer specifically to that type of inheritance in which the characters "blend," that is, the offspring (F_1 hybrid) possesses a character more or less intermediate to those of the parents. This is especially true in the case of size characters. The F_2 generation however, exhibit so much variability that size inheritance is also expressable by Mendelian notation.

In presenting the foregoing account, the writers merely desire to give to the average tobacco grower the underlying facts about hybridization which are now generally accepted and at the same time honor the memory of the discoverer of the laws of heredity. Indeed, detailed knowledge of heredity in tobacco and, in fact, in all living forms in general, involves vast and complex problems for which even over a long period of time, it would be impossible to reach conclusive explanations or solutions. At any rate, the grower's as well as the manufacturer's concern is merely the ultimate product and not the complicated extensive technical and mathematical studies involved.

When hybridization is practiced, the work is started with a definite ideal in mind so that the parent plants selected may possess as many as possible of the qualities sought in the new form. An illustration of this is the attempt of the Connecticut Agricultural Experiment Station to combine the well-shaped (rounded) leaves of the Sumatra variety with the large size and excellent qualities of the Havana. After ten years of constant selection, the efforts of the station were finally crowned with the successful production of the now known Connecticut round tip variety. We say "variety" because it differs from any other known standard variety and it breeds true just as the Sumatra or the

Havana types. This point should indeed be noted carefully. A new plant or strain may be produced by hybridization, but it continues to be called a hybrid only so long as it exhibits great variability. As soon as it breeds true, it is no longer known as a hybrid but as a variety. As it may be recalled, this resulting combination of the round tip of the Sumatra and the large size of the Havana has been brought about in much the same way as the tall-white flowered peas resulted from a cross between tall-colored and dwarf-white parents.

In practice, a sufficiently large number of the third (F_3) generation is propagated in "pure line" cultures (head-to-the-row) in order to test the possibility of obtaining the desired combinations of characters. While mathematically and by expert work, definite results may be obtainable in the fourth or fifth generations, the vast operations involved sometimes delay results for ten years or more. Ordinary selection methods conducted in limited cultures are therefore resorted to instead.

Utilization of first filial generation hybrids in crop improvement with special reference to tobacco.—Hybrid vigor in plants was first observed about two centuries ago by Kolreuter, but it was only in 1917 that the phenomenon was satisfactorily accounted for as being due to the complementary action of dominant factors and termed "heterosis" by Jones of the Connecticut Agricultural Experiment Station, U. S. A.

In the United States and in Europe, especially among seed and plant dealers, hybrid vigor has long been utilized but apparently, up to the present time, it is being neglected in the Philippines. The only instance of its application locally is the Alunan (Badila x P. O. J. 24) and P. S. A. 14 sugar cane. Of course, it is also manifested in some native fruits, but this is not realized.

The utilization of hybrid vigor or heterosis is based chiefly on the established law of heredity to the effect the "when pure races or strains are crossed, the population composing the first filial generations is similar to the parents in uniformity." This is mathematically expressed from the observation that if any particular factors XX and xx are pure or homozygous in the parents, only Xx individuals can be formed in the F_1 generation. This law of heredity therefore satisfies a primary essential in crop production—uniformity.

Because of heterosis the second primary essential in crop production—higher yield—is also obtained. Incidentally other desirable qualities are at least retained if not enhanced.

The utilization of hybrids is generally practicable in the case of plants that are reproduced asexually. Otherwise, it is subject to limitations which are primarily and obviously governed by the facility of making the crossing and the profitableness of the resultant yields of the crosses.

As regards crops, especially annual ones reproduced or propagated only by seeds, the limitations are greater. Aside from those already given, the fact that the operation of crossing must be performed yearly in order to insure the supply of fresh seeds limits the production of F_1 hybrid seeds to a few crops.

In the case of tobacco, a plant ordinarily produces 42 pods with a total of about 90,000 seeds. Since it takes only $\frac{1}{2}$ minute to cross a flower, in about half an hour, therefore, the flowers of a plant can be crossed. And assuming only 75 per cent viability of the 90,000 seeds, one can grow about 3 hectares of tobacco from the seeds of one plant alone. Leaves produced from F_1 wrapper tobacco hybrids have actually been sold for ₱8 per kilo.

The advantages of F_1 hybrids are (1) immediate results, (2) increased yield, (3) improved quality, (4) maximum uniformity, (5) higher seed viability, and (6) rapid growth.

Through hybridization followed by selection, it takes from 4 to 20 years to obtain uniformity, and once this is attained, the question of yield cannot be guaranteed to equal even that of the higher yielding parent since homozygosity is synonymous with the absence of heterosis.

It is obvious that the best descendant of a cross cannot exhibit any superior trait to any identical trait of either of its parents.

The real reason why seeds of most annuals purchased from American and European seed dealers produce uniform and vigorous plants the first year and fail to repeat the performance the following year, is that they are really F_1 hybrids. Seed dealers in these continents thrive well because they possess the secret and the original races of the parents of the desirable F_1 hybrids. The original races are continually inbred and at the same time fresh F_1 hybrids are produced yearly.

ACCLIMATIZATION

It is a well-established fact that some plants are grown to better advantage in some localities than in others. When an effort is made to introduce a foreign valuable plant into a new

locality, it does not usually follow that the plant retains the same characteristic in the same degree as it did in its former environment. Differences of soil and climate conditions may be the factors directly responsible for contrary behavior. There are cases, however, where in the course of two to five years of continuous testing, the plant will finally thrive normally in its new home. The testing of the plant in a new locality, therefore, for the purpose of introducing it to this locality, is called acclimatization, and the result of the tests may either be negatively or positively economical.

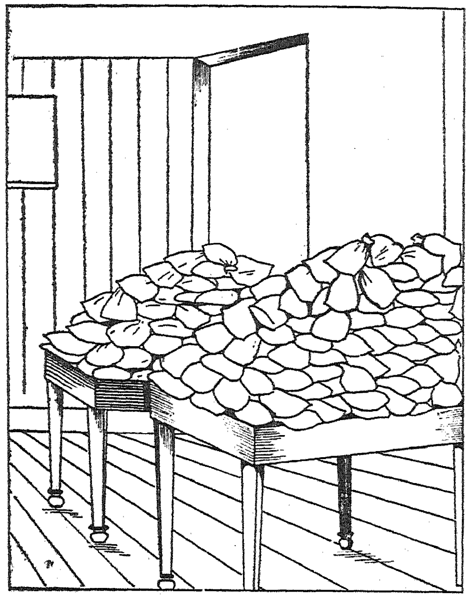

FIG. 7. Bags of tobacco seeds thoroughly cleaned ready for distribution.

There is no better example of this method of improving wrapper tobacco than the attempt to introduce Cuban and Sumatra varieties into the Connecticut Valley. In spite of all kinds of cultural as well as selection efforts to produce a desirable wrapper strain from introduced seed of the famous Sumatra variety, and while the plants to all appearances resembled the genuine or original strain, the quality of the product was always decidedly inferior; finally all attempts to acclimatize it were abandoned. On the other hand, seed of the Cuban variety with the aid of selection, not only thrives favorably in Connecticut but its size, quality, and flavor are even superior. It is now used for growing under artificial shade to the complete exclusion of Sumatra.

MUTATION IN TOBACCO

When a different plant is derived from a parent plant by means of a sudden leap, a result of its seed being grown in separate cultures, and when it breeds true, just as the rest of the seed of the parent plant, to the characters which have distinguished it constantly from generation to generation, it is claimed that the

new plant is either a new variety or a new species, and it is called a mutant or sport—that is, it is produced by mutation. Because of this assertion, the well-known Stewart Cuban tobacco, which originated from a field of a supposedly pure strain of Cuban tobacco, is called a mutant. The Stewart Cuban produces 72 leaves, acquire considerable height, and flowers late as compared with the normal original Cuban which has a mean of 19.9 leaves only.

While mutants are decidedly dependent upon chance, it is well that the grower or the breeder be always on the lookout for them.

SEED SEPARATION

It has been proven that a plant, however healthy or vigorous it may be, produces a considerable quantity of light seeds, and that these seeds do not produce such healthy plants as the heavy one. These facts render the production of uniform crop very uncertain. The case is similar to that of a sickly child born of healthy parents whose other children are all robust and sturdy.

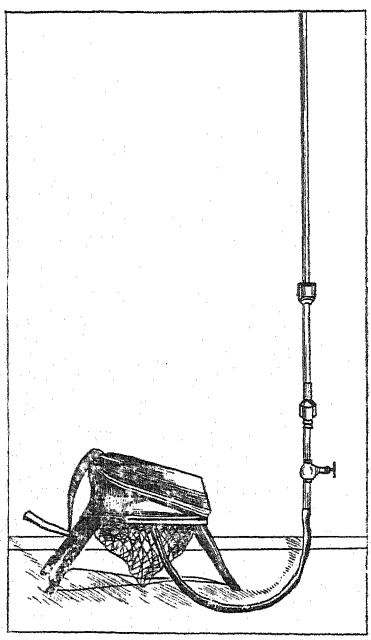

FIG. 8. Apparatus for cleaning tobacco seed.

While various ways may be used to bring about the separation of heavy from light seeds, among which is winnowing, a very convenient apparatus called the tobacco seed separator has been successfully devised by Shamel and Cobey of the U. S. Department of Agriculture. By the improved apparatus a current of air is generated by stepping on the foot bellows. The air passes through the rubber tube and then through the glove valve which regulates the passage of the desired amount of air to accomplish the best separation. The air proceeds through a half inch wide iron tube and then goes out of the top of a larger glass tube, carrying with it the undesirable light seeds. A metallic joint covered with fine wire gauze to prevent the seed from falling into the bellows, is located at the base of the one-

inch glass tube which is 5 to 6 feet long. By using about an ounce of seed at each operation, a pound of seed may be separated in less than half an hour.

The apparatus is cheap and can be prepared at home with the help of a mechanic. It is now purchaseable from hardware or chemical supply houses. Being of common use, it is advisable that a group of growers coöperatively own one well-made apparatus. In the Philippines at one time every municipal government in the tobacco districts owned one tobacco seed separator for the general use of its citizens. Growers took their seed to the town hall where the apparatus was always available.

APPENDIX A

CLASSIFICATION AND BAILING OF SUMATRA WRAPPERS

Sumatra wrappers are first classified according to color and soundness as follows:

Dutch abbreviations or markings	*English descriptions*
L	Very light brown
LB	Light brown
LL	Light brown, slightly speckled
BBL	Light brown, speckled
V	Fallow (mousy brown)
LV	Light fallow—the most prized color
VV	Dark fallow
SV	Fallow, slightly speckled
B	Brown
SB	Brown, partly speckled
BB	Brown, speckled
D	Dark Brown
SD	Dark brown, slightly speckled and broken
BD	Dark brown, speckled
K	Assorted, clean but lifeless
SK	Assorted, dirty and lifeless
KL	Light but lifeless
X	Broken or worm-eaten
XX	Badly broken
O	Discarded, thrash and refuse

After the color classification, the leaves are sorted according to four sizes only. There are no standard lengths but the crop of each year is sorted into four sizes for convenience. Consequently, when the year is favorable, the first size-class may be much longer than the same class of an unfavorable year. As a rule however, the leaves may fall within 15–, 25–, 30–, 38–, and 46–centimeter lengths.

After sorting, the leaves are rebundled into 35 or 40 in each bundle, after which, they are ready to be pressed and baled.

The baling apparatus used in Sumatra is the same as that used in the Philippine, but the methods of arranging the leaves in the bales as well as the general handling of the apparatus are markedly different. Without counting the number of the bundles, a lot weighing 80 kilograms is placed in a collapsible wooden receptacle 30 inches square and over 2 feet high and this slides under the press on rollers. Pieces of tightly woven pandan mattings are placed above then below the receptacle after the bundles have been put in, with the petioles pointing outward. The receptacle is then placed exactly under the press, the iron cover is lowered, the sides are removed, and pressing is continued until the bale has been squeezed to about a foot in height only. Bales of Sumatra tobacco are of uniform size, that is, 30 by 30 inches by 9 to 12 inches in height depending on the size of the leaves to be baled. The bigger the size the higher the bale.

When the desired height of the bale has been reached, the matting at the top and bottom are pulled together and sewed up. The bale is removed, marked with the grade and other identification marks and is ready for shipping. The method of regulating the pressure exerted in the baling of tobacco as observed in Sumatra and in Cuba undoubtedly is a very sound practice. The leaves are not deprived entirely of the necessary moisture for maintaining the so-called 'life" of sound cigar tobacco in general and of wrapper tobacco in particular.

The bales of Sumatra tobacco are usually marked thus—

BK/1917/XLV/3

BK stands for the sign or mark of the estate in which the crop was raised.
1917 stands for the year of the crop.
4 stands for the shipment series (that is, the 4th shipment).
XLV stands for broken leaves of light fallow color.
3. means that the size of the leaves is that of the 3rd group.

Appendix B

CLASSIFICATION AND BALING OF SHADE-GROWN TOBACCO IN CUBA

Classification.—The sound leaves par excellence are sorted out according to size into three main groups which in turn are subdivided into three main kinds of fineness.

A. First—1a/10a, S(Dry), 1a/10a, F(fine), and 1a/10a, Mt. (Medium).

Second—11a/12a, S(Dry), 11a/12a, F(fine), and 11a/10a, Mt. (Medium).

Third—13a, S(Dry), 13a/ F(fine), and 13a/ Mt. (Medium).

There is no exact standard for size because the size of any one leaf depends on the season. Suffice it to say that the first group represents the largest, which are about 50 cm. in length, and the last represent the smallest of the most perfect and sound wrappers (from 1a/ to 15a/). "S" is the abbreviation for *Seco* or *Ligero,* "F" for *Fina* and "Mt" for *Medio Tiempo.*

B. Leaves of the same sizes as above but which, due to some flaw or other cannot be included in any of the A sets. They are designated as *rezagos.*

1st-1a/3a. Rgo. 1a/ S. Rgo. 1a/F. Rgo. 1a/MT.

2nd-4a/ Rgo. 2a/ S. Rgo. 2a/F. Rgo. 2a/Mt.

3rd-5a/ Rgo. 3a/ S. Rgo. 3a/F. Rgo. 3a/MT.

C. Besides these, there are two other *Rezago* classes designated as Rgo. 6a/7a, that include the leaves not up to the 1a/5a class.

D. Still further extra grade, which is suitable as binder either, as 14a/ F. and 14a/ S. or 16a/ Rgo.

E. Likewise a clean grade of filler known as (15a/ or 16a/)

F. A type of filler known as *dispalillable* is also separated and is designated 16a/–17a/.

G. Two grades known as *Volados* are obtained:

Volado No. 1 includes all large leaves which are chaffy greenish (*volado, verdosa, sin vida y vaciada*). These can be fixed up so that they can be used for filler. A leaf may supply enough tobacco for a cigar.

Volado No. 2 Includes similar but decidedly small leaves.

Volado No. 1 are usually discarded from the larger classes and should be inferior to Rgo. 1a/Volado No. 2 are discarded from the filler grade 17a/.

H. A filler grade of coarser texture is separated from the ordinary filler grades, 15a/16a and is called 15a/*de Calidad.*

I. Two grades known as *Quebrados:*

Quebrado No. 1 consists of heavier or rougher leaves Rgo. 4a/5a.

Quebrado No. 2 consists of leaves under the same conditions but derived from other than the preceding. It is distinguished from the *Volados* in that the latter are of lighter texture.

J. Two grades known as *Sentidos:*
Sentido No. 1. Large partly decayed leaves.
Sentido No. 2. Small partly decayed leaves.

K. Two grades of clear cut yellow or very pale leaves:
Amarillo No. 1 (large) and *Amarillo No. 2* (small).

L. *Bote* includes all that cannot be classified with any of the above.

TABLE I.—*Number of leaves in each hand*

Representative grades	*No. of leaves*
1a/10a—*Rgo. 1a*	35
11a/12a—*Rgo. 2a*	40
13a/*Rgo. 3a*	45
14a/*Rgo.*	60
Rgo. 4a	50
Rgo. 5a	55
Qdo. 1a	50
Qdo. 2a	55
Volado 1a	40
Volado 2a	In *gavillas* (1/4) of a hand *bultos*
15/16a	8 ounces *gavilla*
1a	are baled in *gavillas* without being bundled into *manojos.*

TABLE II.—*Classification terms and equivalents*

1 *Tercio* = 50 *cujes* (poles) in *mancuernas* (pair of grown leaves harvested with stalk).
1 *Tercio* = 110 *cujes* of primed leaves.
1 *Tercio* = 550 cujitos (short poles) of primed leaves.
1 *Tercio* = 80 *manojos* (hand).
1 *Manojo* = 4 *gavillas.*
1 *Gavilla* = 33 to 60 leaves of wrapper or binders.
1 *Gavilla* = 6 oz. leaves of fillers.

Baling.—After the leaves have been classified, they are rebundled or retied into hands according to Table I. A hand is tied with raffia fiber which is wound around it spirally so that it becomes fusiform in shape. The hand at the base of the leaves is tied with one of the leaves constituting the hand itself. The hands are then ready to be baled right away. As a rule when the weather permits, the classified leaves are baled the same day.

The baling apparatus is a simple thing. It consists of flat, rather heavy boards 2.5 meters long supported at the middle of its sides by heavier narrow boards 1.5 meters long. These are connected below the base board by two flat, thinner boards which pass through one side of the apparatus according to the size of the bale to be made. At one end of the connecting boards are set alternately half a dozen holes for the purpose. The connecting boards are 1.2 meters long. On the top of the side boards are 4 slightly tapering small supports which are 15 centimeters apart. Between these supports are a pair of sticks to hold the string for tying the bundle. These supports are 60 centimeters high and 4.5 centimeters square at the top. The two centers have removable sticks with which to hold firmly a broad petiole of the royal palm (*Roystonia regia* Cook) which is the material used exclusively in the baling of tobacco leaves in Cuba. The rope used to tie the bales is derived from the fibrous cortex of a malvaceous plant commonly known as *majaguar* (*Hibiscus tiliaceous.* Lin.).

Four pieces of royal palm petioles are required ordinarily for packing a bale of Cuban tobacco. A piece of these petioles is usually 1 meter by 1.5 meters. As these materials are very strong and very compact, they are ideal for the purpose, besides being cheap and abundant.

A bale always contains only 80 hands irrespective of its grade. The hands are arranged in two layers with the butts of the leaves pointing towards the ends of the bales. The upper and lower layers contain 13 hands each and the central layers 14 hands.

The main feature of this process in that the leaves are not actually pressed by machinery. Only hand pressure is employed. This method is very sensible inasmuch as the moisture which is vital in the conservation of the so-called "life" of the leaf tobacco is not squeezed out. It is possible that the pressing of Philippine tobacco to the limit, it is ventured to say, by the use of powerful mechanical apparatus, is responsible for the deficiency of aroma and flavor so justly complained about by American jobbers, and smokers. Indeed, practically all Philippine leaf tobacco examined by the senior writer while in New York City is wanting in the elastic or pliable property which is an obvious indication that a leaf is not "dead" but "alive."

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Appendix C

STANDARD GRADES OF THE CONNECTICUT HAVANA SEEDLEAF AND BROADLEAF

(Prepared by the Tobacco Standardization Section, United States Department of Agriculture)

I. STANDARD GRADES FOR CONNECTICUT HAVANA SEED—TYPE 51

Key to Grade Marks

Groups	*Qualities*	*Colors*	*Lengths 75 per cent Size Between*
A—Wrappers	1—1st quality	L—Light	15-14″ to 16″
B—Second or binders	2—2nd quality	C—Chestnut or medium	17-16″ to 18″
C—Tops and fillers	3—3rd quality	D—Dark	19-18″ to 20″
X—Brokes and nondescript	4—4th quality	M—mixed colors	21-20″ to 22″
Y—Stemmers	9—Wet tobacco		23-22″ to 24″
			25-24″ to 26″
			27-26″ to 28″

Damaged Tobacco

All damaged tobacco to be marked to show the kind and the percentage (or amount) of damage, after the grade designation. For example A2L25 Black rot 6 layers.

First Factor Group	*Second Factor Qualities*	*Third Factor Colors*	*Fourth Factor Lengths or Sizes*
A	1, 2, and 3	L, C, and D	27, 25, 23, 21, 19, 17
B	1, 2, 3, and 9	L and D	27, 25, 23, 21, 19, 17, 15
C	1, 2, and 9	No color Mark	No length Designated
X	1, 2, 3 and 9	No color Mark	No length Designated

LIST OF CONNECTICUT HAVANA SEED GRADES

Light Wrappers (A Group)

Standard Grade	*Description of Grades*	*Old Grade Mark*
A 1 L 27	Choice quality—26″ to 28″	Light wrapper 28″ Pool 1
A 1 L 25	Choice quality—24″ to 26″	Light wrapper 26″ Pool 1
A 1 L 23	Choice quality—22″ to 24″	Light wrapper 24″ Pool 1
A 1 L 21	Choice quality—20″ to 22″	Light wrapper 22″ Pool 1
A 1 L 19	Choice quality—18″ to 20″	Light wrapper 20″ Pool 1
A 1 L 17	Choice quality—16″ to 18″	Light wrapper 18″ Pool 1
A 2 L 27	Good quality—26″ to 28″	Light wrapper 28″ Pool 2
A 2 L 25	Good quality—24″ to 26″	Light wrapper 26″ Pool 2
A 2 L 23	Good quality—22″ to 24″	Light wrapper 24″ Pool 2
A 2 L 21	Good quality—20″ to 22″	Light wrapper 22″ Pool 2
A 2 L 19	Good quality—18″ to 20″	Light wrapper 20″ Pool 2
A 3 L 27	Fair quality—26″ to 28″	Light wrapper 28″ Pool 3
A 4 L 25	Fair quality—24″ to 26″	Light wrapper 26″ Pool 3
A 3 L 23	Fair quality—22″ to 24″	Light wrapper 24″ Pool 3
A 3 L 21	Fair quality—20″ to 22″	Light wrapper 22″ Pool 3
A 3 L 19	Fair quality—18″ to 20″	Light wrapper 20″ Pool 3

Medium Wrappers (A Group)

Standard Grade	*Description of Grades*	*Old Grade Mark*
A 1 C 27	Choice quality—26″ to 28″	Med. wrapper 28″ Pool 1
A 1 C 25	Choice quality—24″ to 26″	Med. wrapper 26″ Pool 1
A 1 C 23	Choice quality—22″ to 24″	Med. wrapper 24″ Pool 1
A 1 C 21	Choice quality—20″ to 22″	Med. wrapper 22″ Pool 1
A 2 C 27	Good quality—26″ to 28″	Med. wrapper 28″ Pool 2
A 2 C 25	Good quality—24″ to 26″	Med. wrapper 26″ Pool 2
A 2 C 23	Good quality—22″ to 24″	Med. wrapper 24″ Pool 2
A 2 C 21	Good quality—20″ to 22″	Med. wrapper 22″ Pool 2
A 3 C 27	Fair quality—26″ to 28″	Med. wrapper 28″ Pool 3
A 3 C 25	Fair quality—24″ to 26″	Med. wrapper 26″ Pool 3
A 3 C 23	Fair quality—22″ to 24″	Med. wrapper 24″ Pool 3
A 3 C 21	Fair quality—20″ to 22″	Med. wrapper 22″ Pool 3

Dark Wrappers (A Group)

Standard Grade	*Description of Grades*	*Old Grade Mark*
A 1 D 27	Good quality—26″ to 28″	Dark wrapper 28″ Pool 1
A 1 D 25	Good quality—24″ to 26″	Dark wrapper 26″ Pool 1
A 1 D 23	Good quality—22″ to 24″	Dark wrapper 24″ Pool 1
A 1 D 21	Good qualtiy—20″ to 22″	Dark wrapper 22″ Pool 1
A 2 D 27	Fair quality—26″ to 28″	Dark wrapper 28″ Pool 2
A 2 D 25	Fair quality—24″ to 26″	Dark wrapper 26″ Pool 2
A 2 D 23	Fair quality—22″ to 24″	Dark wrapper 24″ Pool 2
A 2 D 21	Fair quality—20″ to 22″	Dark wrapper 22″ Pool 2

Seconds or Binders (B Group)

B 1 L 27	Choice quality light—26″ to 28″	Seconds 28″ Pool 1
B 1 L 25	Choice quality light—24″ to 26″	Seconds 26″ Pool 1
B 1 L 23	Choice quality light—22″ to 24″	Seconds 24″ Pool 1
B 1 L 21	Choice quality light—20″ to 22″	Seconds 22″ Pool 1
B 1 L 19	Choice quality light—18″ to 20″	Seconds 20″ Pool 1
B 1 L 17	Choice quality light—16″ to 18″	Seconds 18″ Pool 1
B 1 L 15	Choice quality light—14″ to 16″	Seconds 16″ Pool 1
B 2 L 27	Good quality light—26″ to 28″	Seconds 28″ Pool 2
B 2 L 25	Good quality light—24″ to 26″	Seconds 26″ Pool 2
B 2 L 23	Good quality light—22′ to 24′	Seconds 24″ Pool 2
B 2 L 21	Good quality light—20″ to 22″	Seconds 22″ Pool 2
B 2 L 19	Good quality light—18″ to 20″	Seconds 20″ Pool 2
B 2 L 17	Good quality light—16″ to 18″	Seconds 18″ Pool 2
B 2 L 15	Good quality light—14″ to 16″	Seconds 16″ Pool 2
B 2 L 27	Fair quality light—26″ to 28″	Seconds 28″ Pool 3
B 2 L 25	Fair quality light—24″ to 26″	Seconds 26″ Pool 3
B 2 L 23	Fair quality light—22″ to 24″	Seconds 24″ Pool 3
B 2 L 21	Fair quality light—20″ to 22″	Seconds 22″ Pool 3
B 2 L 19	Fair quality light—18″ to 20″	Seconds 20″ Pool 3
B 2 L 17	Fair quality light—16″ to 18″	Seconds 18″ Pool 3
B 2 L 15	Fair quality light—14″ to 16″	Seconds 16″ Pool 3

Dark Binders (B Group)

B 1 D 19	Good quality dark binder—18″ to 20″	Dark wrapper 20″ Pool 1

Fillers and Tops (C Group)

Standard Grade	*Description of Grade*	*Old Grade Mark*	
C 1 D 21	Good quality dark—20″ to 22″	Dark wrapper 22″	Pool 3
C 1 D 19	Good quality dark—18′ to 20′	Dark wrapper 20″	Pool 2
C 1 D 17	Good quality dark—16″ to 18″	Dark wrapper 18″	Pool 1
C 1 D 15	Good quality dark—14″ to 16″	Dark wrapper 16″	Pool 1
C 2 D 17	Fair quality dark—16″ to 18″	Dark wrapper 18″	Pool 2
C 2 D 15	Fair quality dark—14″ to 16″	Dark wrapper 16″	Pool 2

Brokes or Nondescript (X Group)

X 1	Good Quality Clean Brokes
X 2	Fair Quality Clain Brokes
X 3	Common Quality Clean Brokes

Stemmers (Y Group)

Y 1	Good Clean Ground Leaves	Fillers
Y 2	Fairly Clean Ground Leaves	Fillers
Y 3	Common and Dirty Ground Leaves	Fillers

Wet tobacco (Mixed Groups)

B 9	Wet-Pick for Binders (Best Wet)	Wet
C 9	Wet-Pick for Fillers (Medium Quality Wet)	Wet
X 9	Wet-Low Grade or Stemming and Nondescript (Common)	Wet

SUMMARY OF CONNECTICUT HAVANA SEED GRADES—TYPE 51

Wrappers (A Group)

A 1 L	27 25 23 21 19 17	Choice Quality Light Wrapper
A 2 L	27 25 23 21 19	Good Quality Light Wrapper
A 3 L	27 25 23 21 19	Fair Quality Light Wrapper
A 1 C	27 25 23 21	Choice Quality Medium Wrapper
A 2 C	27 25 23 21	Good Quality Medium Wrapper
A 3 C	27 25 23 21	Fair Quality Medium Wrapper
A 1 D	27 25 23 21	Good Quality Dark Wrapper
A 2 D	27 25 23 21	Fair Quality Dark Wrapper

Fillers and Tops (C Group)

C 1 D	21 19 17 15	Good quality dark fillers
C 2 D	17 15	Fair quality dark fillers

Brokes or Nondescript (X Group)

X 1	Good quality clean brokes
X 2	Fair quality clean brokes
X 3	Common quality clean brokes

Stemmers (Y Group)

Y 1	Good quality clean stemmers
Y 2	Fairly clean stemmers
Y 3	Common and dirty stemmers

Wet Tobacco (Mixed Groups)

B 9	Wet—Pick for binders (Best Wet)
C 9	Wet—Pick for Fillers (Medium Quality Wet)
X 9	Wet—Low Grade or Stemming and Nondescript (Common)

These grades were prepared by the Tobacco Standardization Section of the U. S. Department of Agriculture on August 28, 1923.

II. STANDARD GRADES FOR CONNECTICUT BROADLEAF–TYPE 52

Strain 521—John Williams
Strain 522—Bantle
Strain 523—Hockman
Strain 524—Barber

Key to Grade Marks

Groups	*Qualities*	*Colors*
A—Wrappers	1—1st Quality	L—Light
B—Seconds or Binders	2—2nd Quality	C—Chestnut or Medium
C—Tops or Fillers	3—3rd Quality	D—Dark
X—Brokes and Nondescript	4—4th Quality	M—Mixed Colors
Y—Stemmers	9—Wet tobacco	

Lengths

	Leaves Averaging in Length	
	Size	*Between*
Lengths not considered except in Short Seconds which are indicated by numbers	43	12″ to 16″
	44	16″ to 20″
	45	20″ to 24″

Damaged Tobacco

All damaged tobacco to be marked to show the kind and the percentage (or amount) or damage, after the grade designation. For example, A2L Black-rot, 6 layers.

Qualities, Colors, and Lengths in Each Group

First Factor Group	*Second Factor Qualities*	*Third Factor Colors*	*Fourth Factor Lengths or sizes*
A	1, 2, 3 and 4	L, C, and D	No lengths designated
B	1, 2, 3, and 9	L and D	44 and 43
C	1, 2, 3, and 9	D	No length designated
X	1, 2, 3, and 9	No color Mark	No length designated
Y	1, 2 and 3	No color Mark	No length designated

LIST OF CONNECTICUT BROADLEAF GRADES

Light Wrappers (A Group)

Standard Grade	*Description of Grade*	*Old Grade Mark*
A 1 L	Choice quality	Light wrapper Pool 1
A 2 L	Good quality	Light wrapper Pool 2
A 3 L	Fair quality	Light wrapper Pool 3
A 4 L	Common quality	Light wrapper Pool 4

Medium Wrappers (A Group)

Standard Grade	*Description of Grade*	*Old Grade Mark*
A 1 C	Choice quality	Medium wrapper Pool 1
A 2 C	Good quality	Medium wrapper Pool 2
A 3 C	Fair quality	Medium wrapper Pool 3
A 4 C	Common quality	Medium wrapper Pool 4

Dark Wrappers (A Group)

A 1 D	Choice quality	Dark wrapper Pool 1
A 2 D	Good quality	Dark wrapper Pool 2
A 3 D	Fair quality	Dark wrapper Pool 3
A 4 D	Common quality	Dark wrapper Pool 4

Long Seconds (B Group)

B 1 L	Good quality light colored	Long sections Pool 1
B 2 L	Fair quality light colored	Long sections Pool 2
B 3 L	Common quality light colored	Long sections Pool 3

Short Seconds (B Group)

Standard Grade	Description of Grade		Old Grade Mark	
B 1 L 44	Good quality light colored	—16″ to 20″	Short sections	Pool 1
B 2 L 44	Fair quality light colored	—16″ to 20″	Short sections	Pool 2
B 3 L 44	Common quality light colored	—16″ to 20″	Short sections	Pool 3

Short Seconds (B Group)

B 1 L 43	Good quality light colored binder	—12″ to 16″	Short sections	Pool 1
B 2 L 43	Fair quality light colored binder	—12″ to 16″	Short sections	Pool 2
B 3 L 43	Common quality light colored binder	—12″ to 16″	Short seconds	Pool 3

No. 2 Seconds (B Group)

B 1 M	Good quality off colored binder	No. 2 sections	Pool 1
B 2 M	Fair quality off colored binder	No. 2 sections	Pool 2
B 3 M	Common quality off colored binder	No. 3 sections	Pool 3

No. 2 Dark Wrappers (B Group)

Standard Grade	Description of Grade	Old Grade Mark	
B 1 D	Good quality	No. 2 Dark wrapper	Pool 1
B 2 D	Fair quality	No. 2 Dark wrapper	Pool 2
B 3 D	Common quality	No. 2 Dark wrapper	Pool 3

Fillers or Tops (C Group)

C 1 D	Good quality fillers	Tops	Pool 1
C 2 D	Fair quality fillers	Tops	Pool 2
C 3 D	Common quality fillers	Tops	Pool 3

Brokes and Nondescript (X Group)

X 1	Good quality clean	Brokes	Pool 1
X 2	Fair quality clean	Brokes	Pool 2
X 3	Common quality clean	Brokes	Pool 3

Stemmers (Y Group)

Standard Grade	Description of Grade	Old Grade Mark	
Y 1	Good clean ground leaves	Fillers	Pool 1
Y 2	Fairly clean ground leaves	Fillers	Pool 2
Y 3	Common, dirty ground leaves	Fillers	Pool 3

Wet Tobacco (Mixed Groups)

B 9	Wet—Pick for Binders (Best wet)	Wet
C 9	Wet—Pick for Fillers (Medium quality wet)	Wet
X 9	Wet—Low Grade or Stemming and Nondescript (Common)	Wet

REMARKS

Tobacco is graded under the standard system according to quality, color and length. The quality factor is divided into groups of similar quality in order to simplify the grading. Assorting (sometimes called grading) is the act separating tobacco into lots of like quality, color and length. Grading is the act of examining a lot of tobacco (after it has been assorted) and determining into what grade it belongs.

SELECTED BIBLIOGRAPHY

1. ALLARD, H. A. The mosaic disease of tobacco. U. S. Dept. of Agri. Bull. 40 (1914): 33.
2. AMES, J. W. and G. E. BELTZ. Influence of fertilizers on composition and quality. Ohio. Agri. Expt. Sta. Bull. 285 (1915).
3. ANONYMOUS. Catechism on leaf tobacco production. Philippine Dept. of Agri. and Nat. Res., Bull. (1924). Agri. Cir. 147.
4. BABCOCK, E. B. and R. E. CLAUSEN. Genetics in relation to agriculture (1916): 675. New York.
5. BAILEY, L. H. Cyclopedia of American horticulture (1910): p. 1088, New York.
6. BAKER, C. F. Propagation of tobacco in Cuba. Estación agronómica de Cuba, Bull. 10 (1908): 22.
7. BEINHART, E. C. Steam sterilization of seed beds for tobacco and other crops. U. S. Dept. of Agri. Farmers' Bull. 996 (1918): 15.
8. BRIGGS, L. J. The field treatment of tobacco root-rot. U. S. Dept. of Agri. Bur. of Plant Industry Cir. 7 (1908): 8.
9. BRITTON, W. E. Insect enemies of tobacco crop in Connecticut. Ct. Agri. Expt. Sta. Rpt. for 1906, pp. 263–279.
10. ——— Tabacco bud worm in Connecticut. Ct. Agri. Expt. Sta. Rpt. for 1909–1910, pp. 367–368.
11. BRITTERWECK, OTTO C. The culture of tobacco. U. S. Dept. Agr. Bull. 82.
12. CALVINO, MARIO. Tobacco. Informe de 1917–1918 de la estación experimental agronómica de Cuba, pp. 371–383.
13. CHAPMAN, G. H. "Mosaic" and allied diseases, with special reference to tobacco and tomatoes. 25th An. Report Mass. Agr. Expt. Sta. (1913): 94–104.
14. ——— The sterilization of tobacco seed beds. Mass. Agr. Coll. Extension Bull. 18 (1918): 6.
15. ——— Tobacco growers need experimental help. Hartford County Farm News, Vol. 111, No. 5 (1919): 1–4.
16. ——— Experiments in curing and fermentation of Connecticut shade tobacco. Conn. Agr. Expt. Sta. Bull. No. 3 (1922).
17. CLARA, F. M. Diseases of tobacco (*Nicotiana tabacum* L.) in the Philippines. Phil. Bu. of Agri. Circular 171 (1925): Manila, P. I.
18. ——— A new bacterial leaf diseases of tobacco in the Philippines. Phytopathology, 20 (1930): 691–706, U. S. A.
19. CLINTON, G. P. Tobacco diseases. Ct. Agric. Expt. Sta. Rpt. for 1903, pp. 362–363.
20. ——— Tobacco diseases. Ct. Agric. Expt. Sta. Rpt. for 1904, pp. 328.
21. ——— Fungus disease of tobacco. Ct. Agric. Expt. Sta. Rpt. for 1905, pp. 276–277.
22. ——— Tobacco diseases. Ct. Agric. Expt. Sta. Rpt. for 1906, pp. 324–329.

23. CLINTON, G. P. Sumatra disease. Ct. Agric. Expt. Sta. Rpt. for 1907–08, pp. 360–361.
24. ——— Root-rot tobacco. Ct. Agric. Expt. Sta. Rpt. for 1906, pp. 342–368.
25. ——— Root-rot of tobacco. Ct. Agric. Expt. Sta. Rpt. for 1907–08, pp. 363–368.
26. ——— Chlorosis of plants with special reference to calico of tobacco. Ct. Agric. Expt. Sta. Rpt. for 1914, pp. 358–422.
27. ——— Tobacco lightning injury. Ct. Agric. Expt. Sta. Rpt. for 1915, p. 448.
28. COOK, M. T. and W. T. HORNE. Insects and diseases of tobacco. Estación Central Agronómica de Cuba, Bull. 1 (1905): 23.
29. CRAWLEY, J. T. Fertilizers. Estación Central Agronómica de Cuba, Bull. 14 (1908): 35.
30. CRUZ, FRANCISCO. Abono para el tabaco. Estación Experimental Agronómica de Cuba, Cir. No. 4 (1915).
31. DUGGAR, B. M. Fungous diseases of plants. (1909): 50. Boston.
32. EAST, E. M. The rôle of selection in plant breeding. Popular Sc. Monthly, Aug. (1910): 191–203.
33. ——— The rôle of hybridization in plant breedings. Popular Sc. Monthly, Oct. (1910): 342–355.
34. ——— The mendelian notation as a description of physiological facts. American Naturalist, Vol. 46 (1912): 633–655.
35. ——— The chromosome view of heredity and its meaning to plant breeders. American Naturalist, Vol. 49 (1915): 457–494.
36. ——— Studies in size inheritance in nicotiana. Genetics Vol. 1 (1916): 164–176.
37. ——— The home of the sovereign weed. The Scientific Monthly, Aug. (1918): 170–178.
38. ——— and H. K. HAYES. Heterozygosis in evolution and in plant breeding. U. S. Dept. of Agric. Bur. of Plant Industry Bull. (1912): 243–258.
39. ——— and F. D. JONES, and Inbreeding and outbreeding. (1919): 285. Philadelphia.
40. EDROZO, LEON B. A study of tobacco worms and methods of control. The Philippine Agriculturist and Forester, 6: (1918) 195–209, Los Baños, P. I.
41. FIPPIN, E. O. Soil survey of the Connecticut Valley. U. S. Dept. of Agric. Bur. of Soils Rpt. 1903, pp. 38–61.
42. FLOYD, M. L. Cultivation of cigar-leaf tobacco in Florida. U. S. Dept. of Agric. Rpt. 62 (1899): 31.
43. ——— Bulk fermentation of Connecticut tobacco. U. S. Dept. of Agric. Bur. of Soils Circ. 5 (1919): 10.
44. FREAR, WILLIAM and E. K. HIBSHMAN. The production of cigar-leaf tobacco in Pennsylvania. U. S. Dept. of Agric. Farmers' Bull. 416 (1918): 20.
45. ——— and OLSON, OTTO. The cigar tobacco industry in Pennsylvania. U. S. Dept. Agr. Gen. Bull. 371 (1922).
46. GARNER, W. W. Methods of testing the burning qualities of cigar tobacco. U. S. Dept. of Agric. Bull. 100 (1906): 14.

47. ——— The relation of the composition of the leaf to the burning qualities of tobacco. U. S. Dept. of Agric. Bur. of Plant Industry Bull. 105 (1907): 27.

48. ——— The present status of the tobacco industry. U. S. Dept. of Agric. Bur. of Plant Industry Circ. 48 (1919): 13.

49. ——— The use of artificial heat in curing cigar-leaf tobacco. U. S. Dept. of Agric. Bur. of Plant Industry Bull. (1912): 241–25.

50. ——— Research studies on the curing of leaf tobacco. U. S. Dept. of Agric. Bull. 70 (1914): 40.

51. ——— Tobacco curing. U. S. Dept. of Agric. Farmers' Bull. 423 (1916): 24.

52. ——— Tobacco culture. U. S. Dept. of Agric. Farmers' Bull. 571 (1917): 17.

53. ——— Important diseases of tobacco in the south. Tobacco, Vol. 49, No. 21 (1920): 28–32.

54. FOUBERT, C. L. and B(CON, O. W. Research studies on the curing of the leaf tobacco. U. S. Dept. of Agr. Bu. Pl. Ind. Bull. 79 (1914).

55. GAGE, CHARLES, E. American tobacco types, uses and markets. U. S. Dept. Agr. Cir. No. 249 (1933).

56. GILBERT, W. W. The root-rot of tobacco caused by *Thielavia basicola*. U. S. Dept. of Agr. Bur. of Pl. Ind. Bull. 158 (1909): 25.

57. GOFF, E. S. Tobacco curing experiments. Wisconsin Rpt. for 1894, pp. 351–371 (Agr. Expt. Sta.)

58. GUTIERREZ, MARIANO. The raising of wrapper tobacco in the Cotabato Valley. The Phil. Agr. Review 17: (1924) 227–236.

59. HASSELBRING, H. Tipos de tabaco cubano. Estación Experimental Agronómica de Cuba, Bull. 23 (1915): 21.

60. ——— Efectos de la sombra sobre la transpiración y la asimilación de la planta de tabaco en Cuba. Estación Experimental Agronómica de Cuba, Bull. 24 (1915): 33.

61. HAYES, H. K. What seed selection and breeding has done for tobacco in Connecticut. American Breeders Rpt. Vol. 7 (1910): 143–152.

62. ——— Correlation and inheritance in tobacco. Ct. Expt. Sta. Bull. 171 (1912): 45.

63. ——— Variation in tobacco. Journal of Heredity, Vol. 5, No. 1 (1914): 40–46.

64. ——— Tobacco breeding in Connecticut. Ct. Agr. Expt. Sta. Bull. 176 (1913): 68.

65. HERNANDEZ, NEMESIO M. The effect of natural fertilizers on the production of tobacco. The Phil. Agrst. Vol. 7, Nos. 9–10 (1919).

66. ——— An experiment on some cultural practices in cigar wrapper production. The Philippine Agricultural Review, *22:* (1929) 363–376.

67. ———Cultural directions for planting wrapper tobacco. The Philippine Agricultural Review, *22:* (1929), 377–388.

68. HINSON, W. M. and JENKINS, E. H. The management of tobacco seed beds. Conn. Agr. Expt. Sta. Bull. No. 166 (1910).

69. HONING, J. A. Tabak van mengsel van typen. Bull. Vam. Het Deli Proefstation, Medan, Sumatra East Coast.

70. HOUSER, T. Yields of tobacco F' hybrids with those of parent plants; comparison of. American Breeders Assn. Rpt. Vol. 7 (1910): 155–167.
71. HOWARD, L. O. Principal insects affecting the tobacco plant. U. S. Dept. of Agr. Farmers' Bull. 120 (1900): 32.
72. JENKINS, E. H. Chemical changes in tobacco during fermentation. Ct. Agr. Expt. Sta. Rpt. for 1892, pp. 28–31.
73. ——— Tobacco curing. Ct. Agr. Expt. Sta. Rpt. for 1897, pp. 223–230.
74. ——— Experiments in curing and fermenting tobacco. Ct. Agr. Expt. Sta. Rpt. for 1899, pp. 286–297.
75. ——— Studies on the tobacco crop of Connecticut. Ct. Agr. Expt. Sta. Bull. 180 (1914): 65.
76. ——— Fertilizer report for 1918. Ct. Agr. Expt. Sta. Bull. 209, pp. 169–170.
77. ——— The management of tobacco seed beds. Ct. Agr. Expt. Station Bull. 166 (1910): 11.
78. JOHNSON, JAMES. The control of damping-off in plant beds. Wisconsin Res. Bull. 31 (1914): 32 (Wis. Expt. Sta.).
79. ——— The control of diseases and insects of tobacco. Wis. Agr. Expt. Sta. Bull. 237 (1914): 34.
80. ——— Black rot, shed burn, and stem rot of tobacco. Wis. Agr. Expt. Sta. Res. Bull. 32 (1914): 23.
81. ——— Management of tobacco soils. Wis. Agr. Expt. Sta. Bull. 277 (1917).
82. ——— Tobacco culture. Wis. Agr. Expt. Sta. Bull. 206 (1919).
83. ——— The inheritance of the branching habit of tobacco. Genetics, Vol. 4 (1919): 307–340.
84. ——— Disease resistant strains of tobacco developed. Wis Agr. Expt. Sta. Bull. 302 (1919): 7–8.
85. ——— and C. M. SLAGG. Tobacco in Wisconsin. Wis. Agr. Expt. Sta. Bull. No. 337 (1921): 7–8.
86. JONES, D. F. Effects of inbreeding and crossbreeding upon development. Ct. Agr. Expt. Sta. Bull. 207 (1918): 100.
87. ——— Connecticut round tip tobacco. Hartford County Farm News, Vol. 3, No. 5 (1920): 6–7.
88. LEAVENS, GEORGE D. Tobacco and its fertilization. Published by the Olemortimer Company, N. York, U. S. A. (1913.)
89. LOEW, OSCAR. Curing and fermentation of cigar-leaf tobacco. U. S. Dept. of Agr. Rpt. 59 (1899): 34.
90. ———Physiological studies of Connecticut leaf tobacco. U. S. Dept. of Agr. Rept. 65 (1900): 57.
91. ——— CATALESE. A new enzym of general occurrence with special reference to the tobacco plant. U. S. Dept. of Agr. Rpt. 68 (1900): 47.
92. MORGAN, A. C. Methods of controlling tobacco insects. U. S. Dept. of Agr. Bureau of Entomology, Circ. 123 (1918): 17.
93. MULDER, EMIL. Cultivation of tobacco in Sumatra. U. S. Dept. of Agr. Rpt. 58, (1898): 39.

94. McNess, George T. and Lewis W. Ayer. Experiment in growing Cuban seed tobacco in Alabama. U. S. Dept. Agr. Bu. Soils Bull. No. 37 (1906).
95. Nesom, G. E. Cultivo del tabaco en Filipinas. Departamento del Interior, Oficina de Agricultura, I. F., Bull. No. 5 (1907).
96. Olson, Otto. Tobacco seed beds. Pennsylvania Agr. Expt. Sta. Bull. 130 (1914): 13.
97. ——— The culture of cigar-leaf tobacco in Texas. Texas Agr. Expt. Sta. Bull. No. 144 (1914).
98. Paguirigan, D. B. The production of cigar-wrapper tobacco in the Philippines. Phil. Agriculturist and Forester, June, (1916): 39–40.
99. ——— Tobacco growing in the Philippines. Phil. Bur. of Agr. Bull. 34 (1919): 26.
100. ——— Tobacco growing in Sumatra. The Phil. Agr. Review, Vol. XVI, No. 1 (1923): 3–11.
101. ———Tobacco growing in Cuba. The Phil. Agr. Review, Vol. XVI (1923): 174–176.
102. ——— Tobacco growing in Sumatra. The Tropical Agriculturist, Vol. LXI, No. 5 (1923): 266–271. Peredeniya, Ceylon. fl. 103.
103. ——— A preliminary report on the effect of distance of planting wrapper tobacco. The Phil. Agr. Review, Vol. XVII, No. 4 (1924): 237–243.
104. ——— Tobacco growing in the Cagayan Valley. Phil. Bur. of Agriculture Circ. 137 (1925): 30.
105. ——— Statistical method in plant breeding. Bur. of Agr. Unnumbered Circ. (1925): 23.
106. ——— Descriptive list with cultural directions of tobacco varieties grown and distributed by the Bureau of Agriculture. Bur. of Agr. Circ. 186 (1925): 7.
107. ——— El cultivo del tabaco en Cuba. La Hacienda, Vol. XXI, Nos. 1 (pp. 27–30) 2 (90–93) & (58–610) Buffalo, N. Y. Jan. Feb., and March, 1925.
108. ——— Notes in the manufacture of tobacco in the Philippines. The Phil. Agr. Review, Vol. XX, No. 1 (1927): 5–82.
109. ——— Wrapper leaf tobacco can be produced from native varieties. Commerce and Industry Journal, Vol. III, No. 6 (1927): 4–14.
110. ——— Acclimating and standardizing tobacco at the Isabela station. Tobacco, Vol. LXXXIV, No. 18 (1927): 17–20. New York City.
111. ——— Some facts about the production of cigars wrapper tobacco in the Philippines. Bur. of Agr. Radio Lectures on Agricultural Topics, Vol. IV, (1928): 157–160.
112. ——— Wrapper tobacco now successfully grown here. The Philippines Herald, Saturday, April 25, 1931, pp. 3, 9.
113. ——— Diversification in the tobacco growing industry. Fortnightly News. Department of Agriculture and Natural Resources. Vol. II, No. 1 (1931): 26–30, 34.
114. ——— Cigar wrapper tobacco production now established. Bur. of Pl. Industry Contributions to Knowledge of Philippine Agriculture. Dept. of Agr. & Nat. Res. (1932): 22–27.

115. PAGUIRIGAN, D. B. Philippine tobacco problems and their solutions. Bur. of Pl. Industry Contributions to Knowledge of Philippine Agriculture. Dept. of Agri. & Nat. Res. (1932); 16–18.
116. ——— Cigar wrapper culture. Farm and Home. Vol. II, No. 4 (1933): 108, 126–127.
117. ——— Agronomic requirements of different types of tobacco raised in the Philippines. Agricultural Life. Vol. 1, No. 3 (1934): 5–7 (con't.) p. 36 and No. 4, pp. 13 and 18.
118. ——— Present philippine standard varieties of tobacco. Philippine Journal of Agriculture 5: (1934) 71–86.
119. ——— and P. UGADE. Cigar wrapper leaf tobacco culture in the Philippines. Bur. of Plant Industry Unnumbered Cir. (1934): 1–7.
120. DE PASS, J. P. Tobacco culture. Florida Expt. Sta. Bull. 19 (1922): 13.
121. PATTERSON, H. J. Tobacco breeding work in Maryland. American Breeders Assn. Rpt., Vol. 7 (1910): 152–155.
122. RIDGEWAY, C. S. Grain of tobacco leaf. Journal of Agri. Review, Vol. 7, No. 6 (1916): 269–287.
123. ROBINSON, T. R. The fertilizing value of hairy vetch. U. S. Dept. of Agri. Bur. of Pl. Industry Cir. 15 (1919): 5.
124. ROGERS, SAM., L. Stocks of leaf tobacco. U. S. Dept. of Com. Bur. of the Census Bull. 139 (1919): 46.
125. RUSSELL, E. J. Soil conditions and plant growth, pp. 58–80, London (1917).
126. SELBY, A. D. and HOUSER, TRUE. Tobacco culture in Ohio. Ohio Agri. Expt. Bull. 238 (1912): 263–359.
127. SHAMEL, A. D. Tobacco breeding experiments in Connecticut. Ct. Agri. Expt. Sta. Rpt. for 1905, pp. 331–342.
128. ——— Tobacco breeders Assn. Rpt., Vol. 6 (1909): 268–275.
129. ——— Tobacco breeding. U. S. Dept. of Agri. Bur. of Plant Industry Bull. 96 (1907): 67.
130. ——— The art of seed selection. U. S. Dept. Agri. (1907 Yearbook).
131. ——— and COBERY, W. W. Varieties of tobacco distributed in 1905–06 with cultural directions. U. S. Dept. of Agri. Bur. of Pl. Industry Bull. 91 (1906): 38.
132. SCHERFIUS, W. H. Tobacco. Ken. Agri. Expt. Sta. Bull. No. 129.
133. SHULTE, J. I. Work of the agricultural experiment stations on tobacco. U. S. Dept. Rpt. 63 (1909): 48.
134. SMITH, E. F. The Granville tobacco wilt. U. S. Dept. of Agri. Bur. of Plant Industry Bull. 141 (1908): 17–24.
135. STEWART, J. B. Effects of shading on soil conditions. U. S. Dept. of Agri. Bur. of Soils Bull. 39 (1905): 19.
136.——— The production of cigar-wrapper tobacco under shade in the Connecticut Valley. U. S. Dept. of Agri. Bur. of Plant Industry Bull. 138 (1908) 31.
137. THORNE, CHAS. E. Experiments with fertilizers on tobacco. Ohio Agri. Expt. Sta. Bull. No. 161 (1905).
138. VAN LEENHOFF, J. Curing and fermenting tobacco. Porto-Rico Agri. Expt. Sta. Bull. 5 (1904): 12–15, 27–29, 38–44.

139. DE VAULT, S. The supply and distribution of Connecticut Valley cigar leaf tobacco. Mass. Agri. Expt. Sta. Bull. 193 (1919): 143–230.
140. DE VRIES, HUGO. Plant breeding. Chicago (1907): 300.
141. WELLINGTON, R. Studies of natural and artificial parthenogenesis in nicotiana. American Naturalist, Vol. 47 (1913): 270–306.
142. WESTBROOK, E. C. The tobacco plant bed. Georgia State College of Agri. Bull. No. 222 (1920).
143. WHITE, O. E. The bearing of teratological development in nicotiana on theories of heredity. American Naturalist. Vol. 47 (1913): 206–228.
144. WHITNEY, M. Tobacco soils of the United States. U. S. Dept. of Agri. Bur. of Soils Bull. 11 (1913) 47.
145. ——— Tobacco soils of Connecticut and Pennsylvania. Reprint from U. S. Dept. Agr. (1905).
146. ——— Growing Sumatra tobacco under shade in Connecticut Valley. U. S. Dept. of Agri., Bur. of Soils Bull. 20 (1902): 31.
147. ——— and MEANS, THOS. H. Temperature changes in fermenting files of cigar-leaf tobacco. U. S. Dept. of Agri. Rpt. 60 (1899): 28.
148. WOLF. F. A. and FOSTER, A. C. Tobacco wildfire. Journal of Agri. Res. Vol. 12, No. 7 (1918): 449–457.

ILLUSTRATIONS

PLATE 1

Bales of filler tobacco in a warehouse of one of the leading cigar factories in Manila, Philippine Islands.

PLATE 2

FIG. 1. Assorting filler tobacco for cigar manufacture.
2. Stemming cigar filler tobacco for cigar manufacture.

PLATE 3

Different brands, shapes and sizes of cigars.

PLATE 4

FIG. 1. A typical plant of the variety "Simmaba" ("Marogui"), Los Baños Economic Garden, Los Baños, Laguna, Philippine Islands.
2. A typical plant of the variety "Ilagan Sumatra," Los Baños Economic Garden, Los Baños, Laguna. This variety is a strain of the genuine Sumatra developed by the Ilagan Tobacco Experiment Station, Ilagan, Isabela, Philippine Islands, by continuous selection.
3. A typical plant of the variety "Viscaya," Los Baños Economic Garden, Los Baños, Laguna, Philippine Islands.

PLATE 5

1. Seedlings forty-five days old ready for transplanting.
2. Tobacco seedlings dusted with calcium arsenate and sterilized dust mixture to control the ravages of worms.

PLATE 6

1. The cultivation of wrapper tobacco by ridging.
2. The cultivation of wrapper tobacco by banking or the so-called, "Sumatra method."

PLATE 7

1. Dusting open-grown wrapper tobacco with calcium arsenate mixtures by the use of a hand dusting machine.
2. Dusting open-grown wrapper tobacco with calcium arsenate mixture by the use of a cheese cloth bag.

PLATE 8

1. Topping and removing suckers of shade-grown wrapper tobacco in Cuba.
2. Gathering wrapper tobacco, Cuba.

PLATE 9

FIG. 1. Growing wrapper tobacco in Cuba under shade of royal palm (*Roystonea regia*) leaves.

2. Wrapper tobacco grown under abacá cloth in Los Baños Economic Garden, Los Baños, Laguna, P. Islands. The sand, lower and middle standard leaves were already harvested.

PLATE 10

1. Wrapper tobacco grown under shade of talahib grass (*Saccharum spontaneum* in Rosales, Pangasinan, Philippine Islands.
2. Wrapper tobacco grown under shade of talahib grass (*Saccharum spontaneum*) in Naguilian, Isabela, Philippine Islands.

PLATE 11

Stringing wrapper tobacco in the Philippines.

PLATE 12

1. Fresh leaves newly strung and hung on the racks to cure.
2. Cured wrapper tobacco ready to be put down and bundled for fermentation.

PLATE 13

1. A typical fermenting house in Sumatra.
2. Classifying and grading wrapper tobacco in Sumatra. Note the adequate ventilation of the building to properly accomplish the grading and classification work.

PLATE 14

A typical cigar factory in the Philippine Islands.

PLATE 15

1. Stemming tobacco in Cuba.
2. Drying stemmed tobacco in Cuba.

PLATE 16

1. Classifying cigars according to color.
2. Sterilizing cigars in a gas heated room before packing.

PLATE 17

1. Cigars in boxes ready to be sealed after the last touch.
2. Banding cigars with beautifully lithographed rings preparatory to sealing the boxes.

PLATE 18

Branding cigar boxes.

PLATE 19

Principal shapes of cigars.

PLATE 20

IG. 1. The true bud worm (*Heliothis virescons* Fab.): *a*, adult moth; *b*, full-grown larva from side; *c* same from above; *d*, seed pod bored into by larva; *e*, pupa ½ natural size. (After Howard.)

2. The tobacco split worm (*Gelechia operculella* Zell). Adult moth above; pupa below at left with side view of enlarged anal segment; larva below at right-all enlarged. (After Howard.)
3. A tobacco cut worm (*Peridromia saucia*): *a*, moth; *b*, normal form of larva, side view; *c*, same in curved position; *d*, dark form of larva from above; *e*, egg, from side *f*, egg mass on twig. All ½ natural size except *e*, which is enlarged. (After Howard.)
4. *Agrotis Ypsilon*, one of the tobacco cut worms: *a*, larva; *b*, head of same; *c*, adult ½ natural size. (After Howard.)

PLATE 21

1. The mosaic disease of tobacco.
2. Tobacco plants severely damaged by tobacco worms.

PLATE 22

1. The suck fly (*Dicyphus minimus*): *a*, newly hatched; *b*, second stage; *c*, nymph; *d*, adult, *e*, head and beak from side—enlarged. (After Howard.)
2. Northern tobacco worm, or "horn worm" (*Phlegethontius quinquemaculata*) *a*, adult moth; *b*, full-grown larva; *c*, pupa ⅔ natural size. (After Howard.)

PLATE 23

1. The tobacco (*Lasioderma serricorne*, Fabr.): *a*, larva; *b*, pupa; *c*, adult; *d*, leaf tobacco severely damaged by beetle *a*, *b*, and *c*. (After Chittenden).
2. Cigars damaged by the tobacco beetle.

PLATE 24

1. A tobacco plant attacked by the fussarium wilt disease.
2. Tobaco plants showing sign of bacterial wilt infection.

PLATE 25

1. Root-knot disease (*Heterodera radicola*). The knots on the roots are typical symptoms of the disease.
2. Sclorotium blight. The constrictions of the attacked parts of the stalks and presence of white fungus micelia are very typical.

PLATE 26

1. Selected plants in a Sumatra variety plot newly bagged to insure self-fertilization. Ilagan Tobacco Experiment Station, Ilagan, Isabela, Philippine Islands.
2. Seed plots at the Hacienda San Antonio, Ilagan, Isabela, of the Compañia General de Tabacos de Filipinas, the biggest tobacco corporation in the Philippines.

PLATE 27

1. Tobacco capsules of a single self-fertilized plant harvested for future planting.
2. A self-fertilized bunch of capsules of a single plant, cover just removed showing the immature pods which should be removed.

PLATE 28

1. Showing how the poles to support the cheese cloth flower bags, should be erected.
2. Showing how the flower heads are covered with cheese cloth bags.

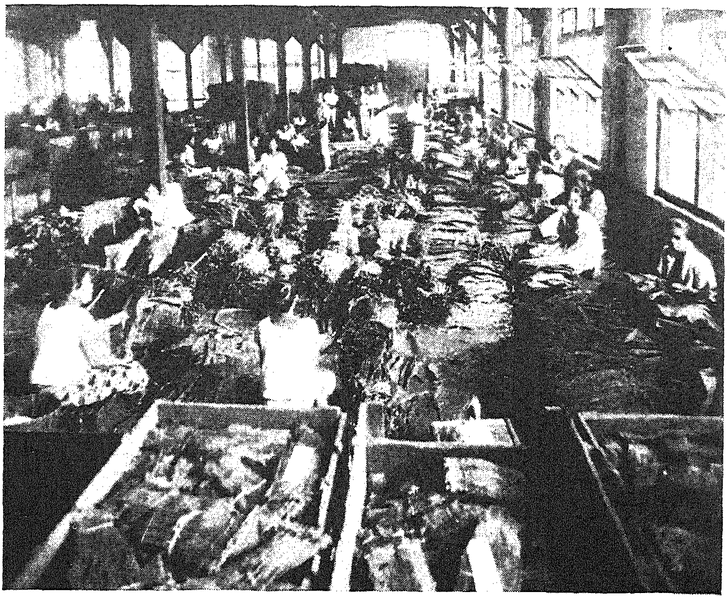
PLATE 29

1. Typical leaves of the variety "Ilagan Sumatra."
2. Typical leaves of the variety "Simmaba" (Marogui).
3. Typical leaves of the variety "Vizcaya."

TEXT FIGURES

FIG. 1. A typical curing shed for wrapper tobacco in Sumatra.
2. A typical curing shed for wrapper tobbaco in Cuba.
3. Typical curing sheds for wrapper tobacco in the Connecticut Valley, U. S. A.
4. Method of sweating wrapper tobacco in the United States.
5. A method of piling wrapper tobacco in Sumatra for the fermentation process.
6. Diagram of a tobacco flower (longitudinal section).
7. Bags of tobacco seeds thoroughly cleaned ready for distribution.
8. Apparatus for cleaning tobacco seed.

PLATE 1.



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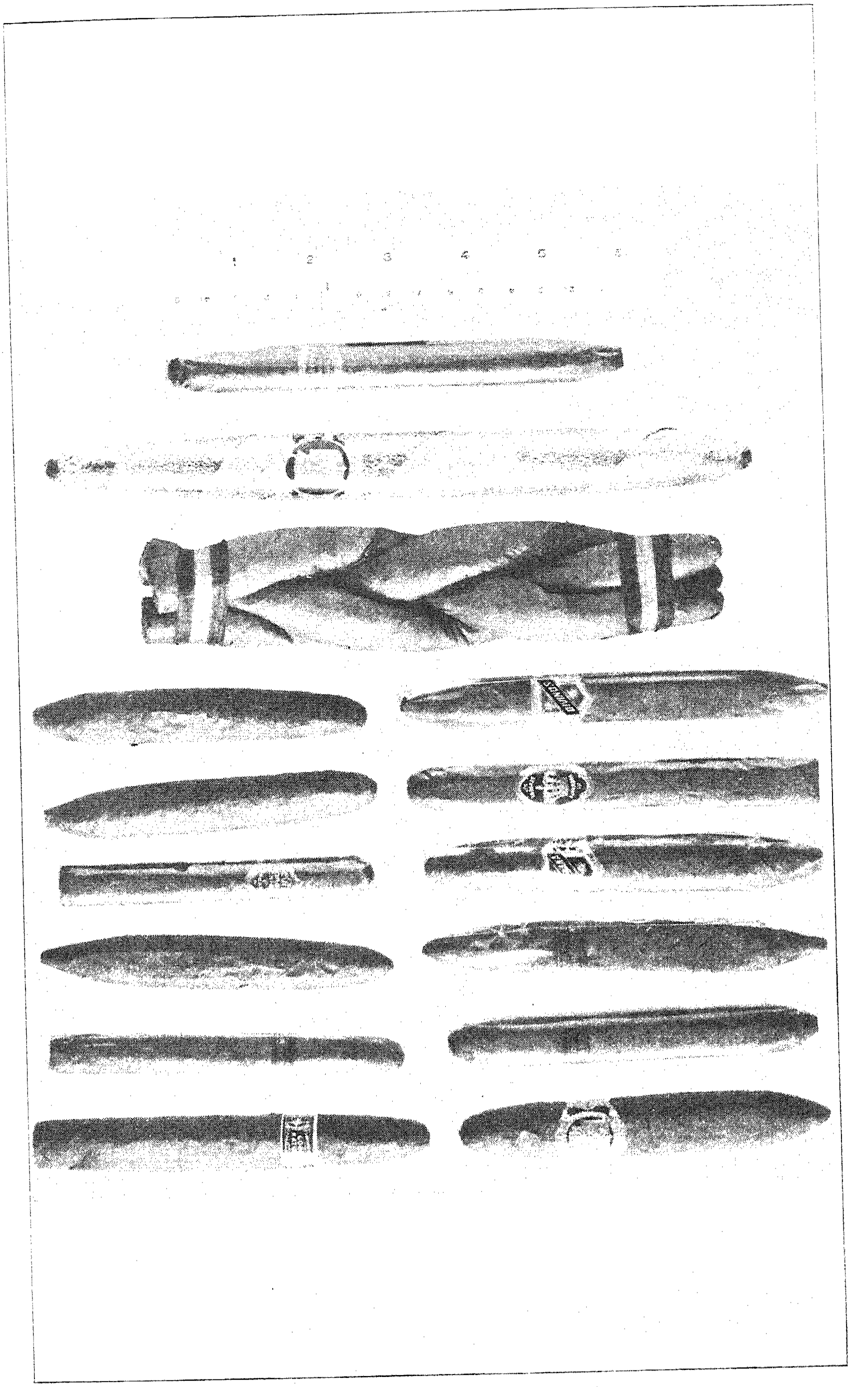

PLATE 3.

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PLATE 4.

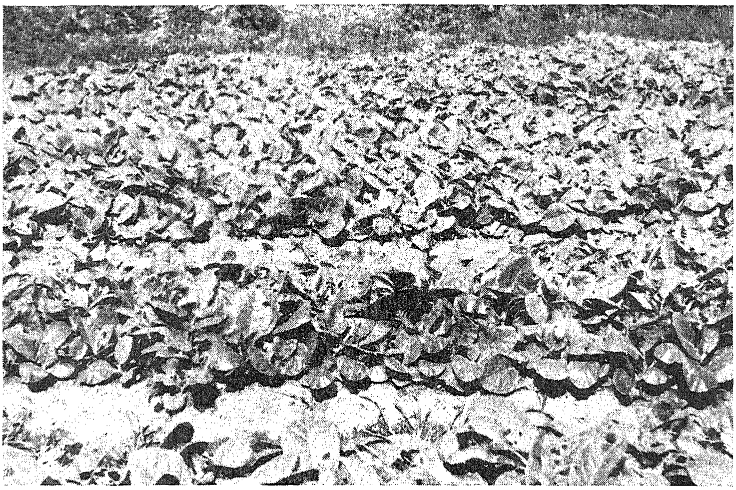

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PLATE 5.

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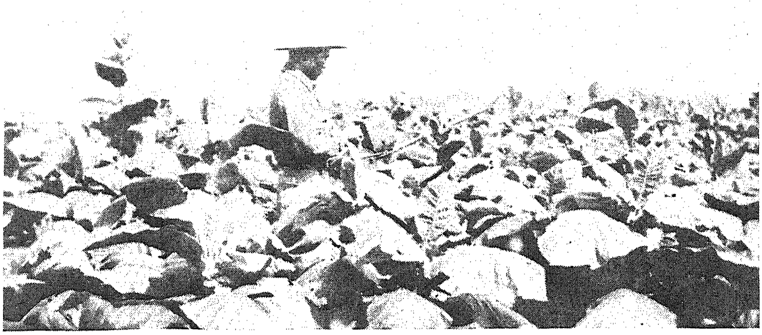

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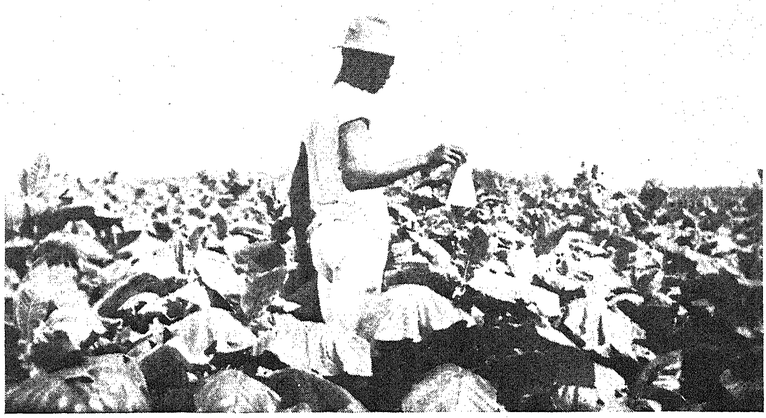

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PLATE 7.

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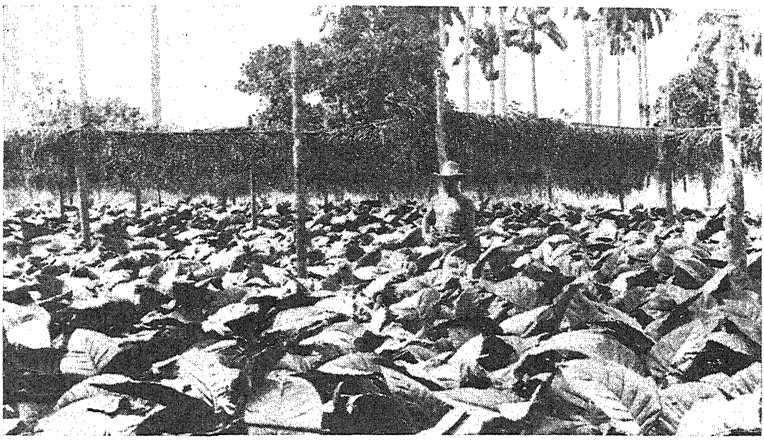

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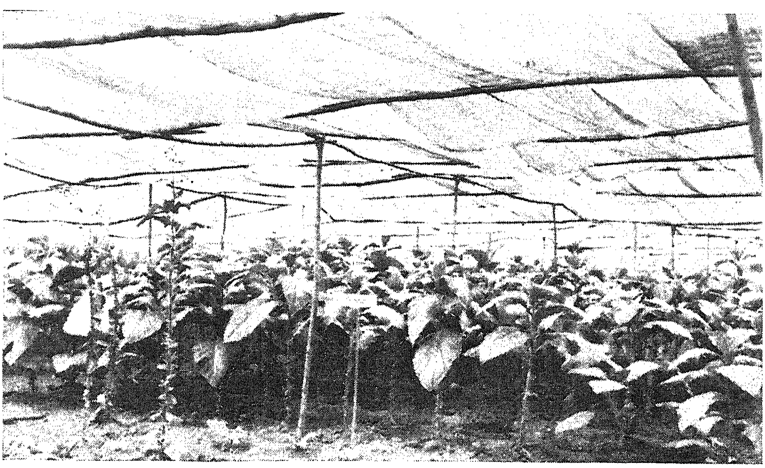

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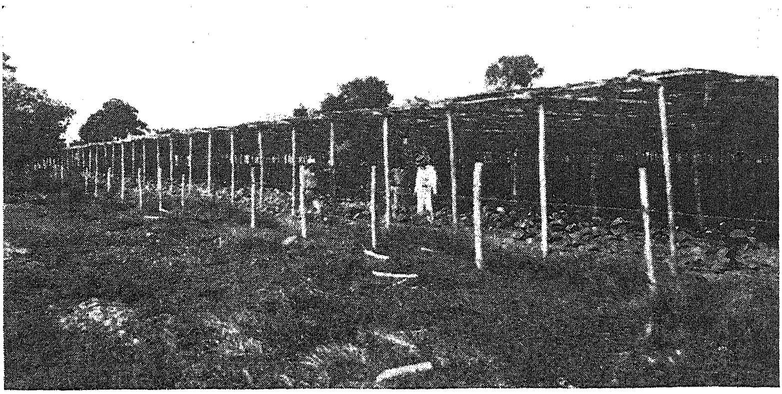

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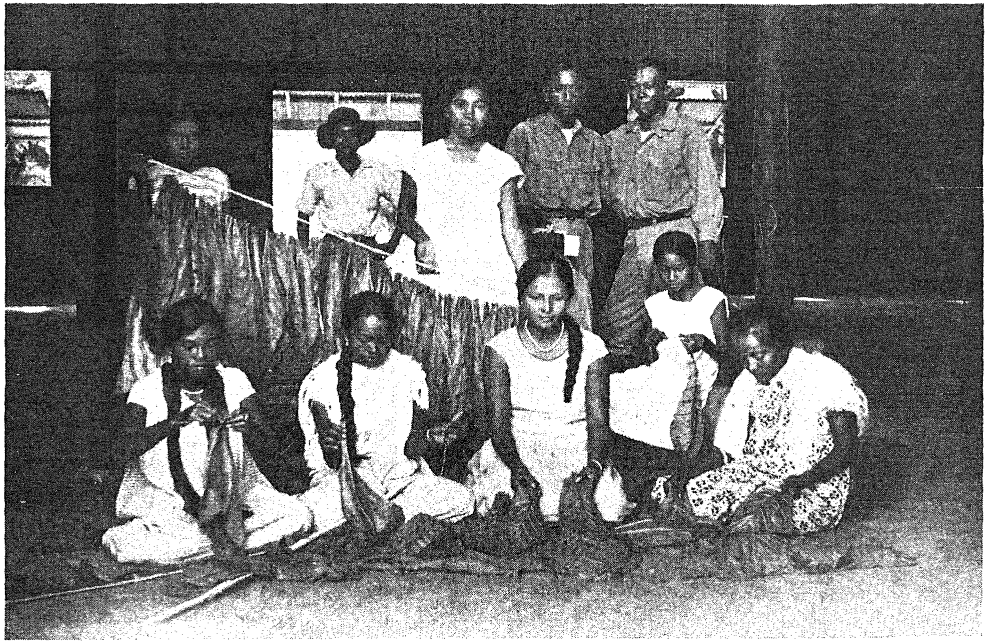

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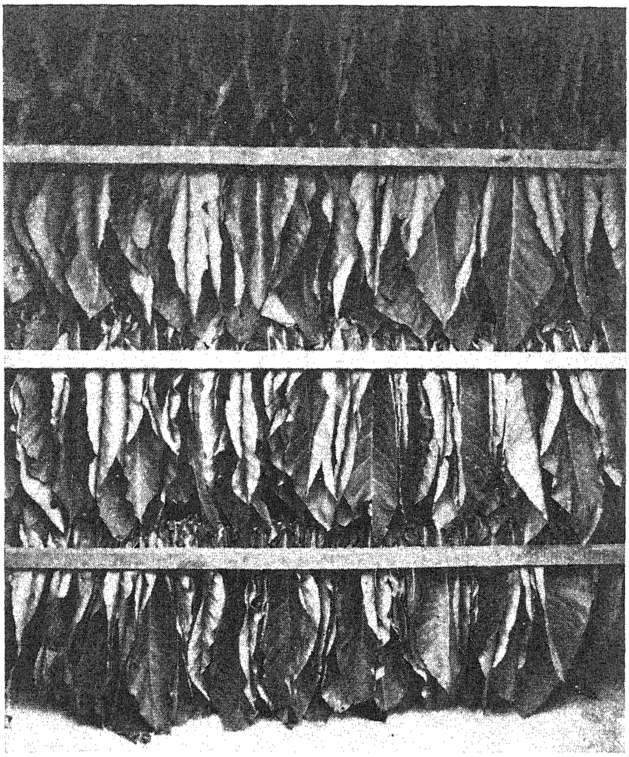

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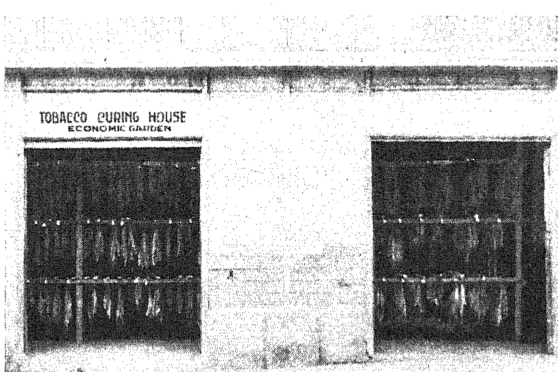

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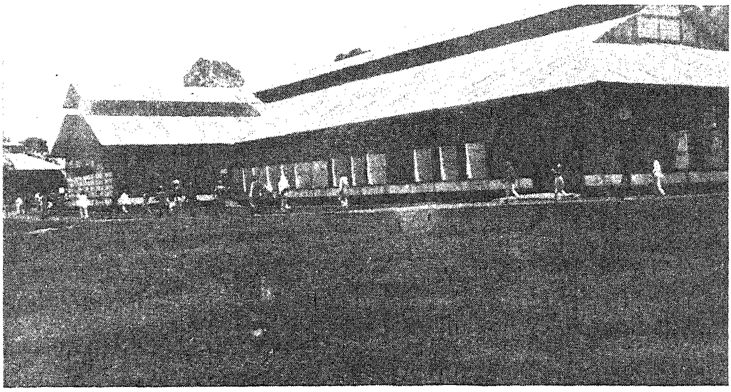
PLATE 12.



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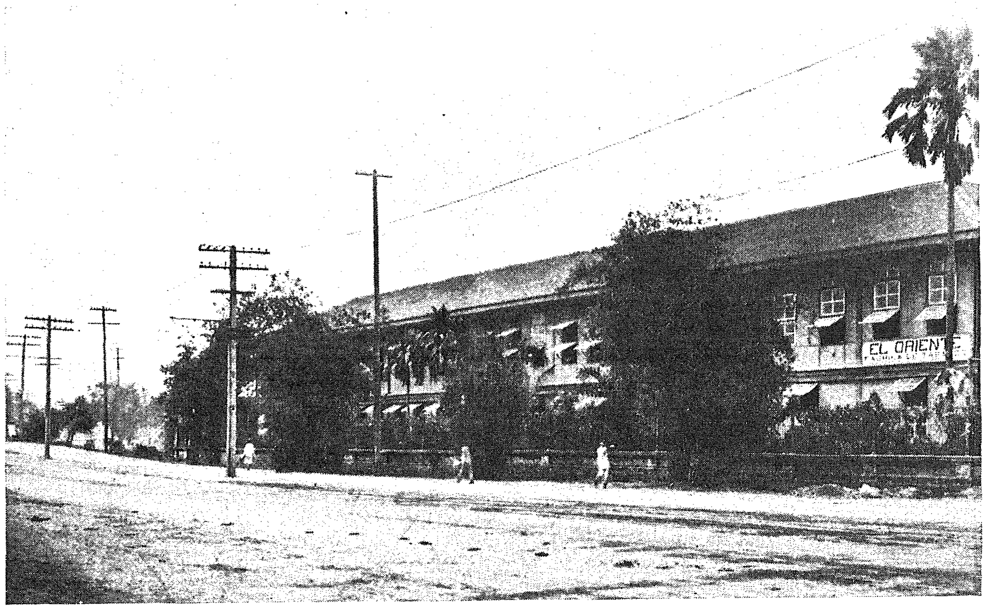

PLATE 14.

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PLATE 15.

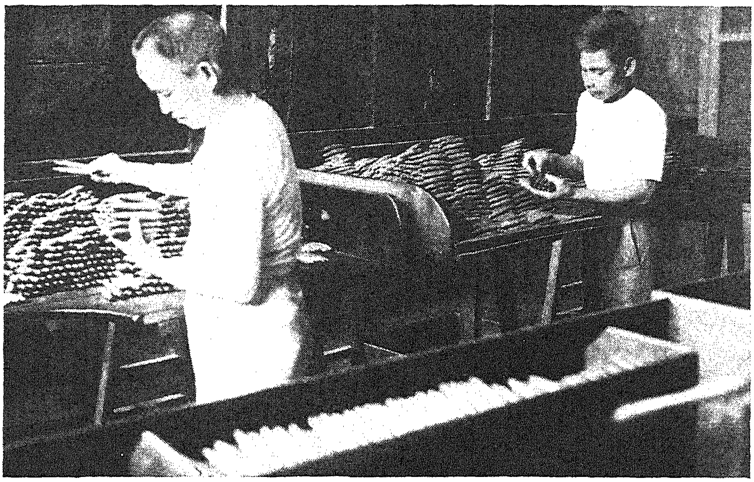

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PLATE 16.

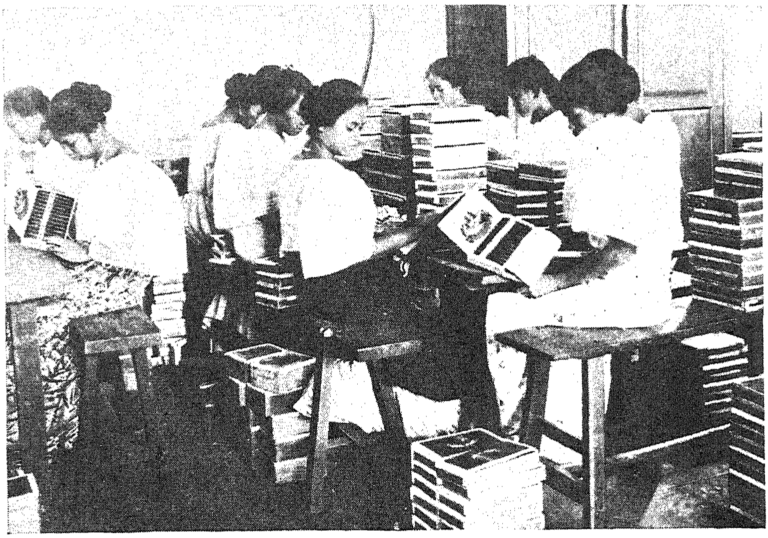

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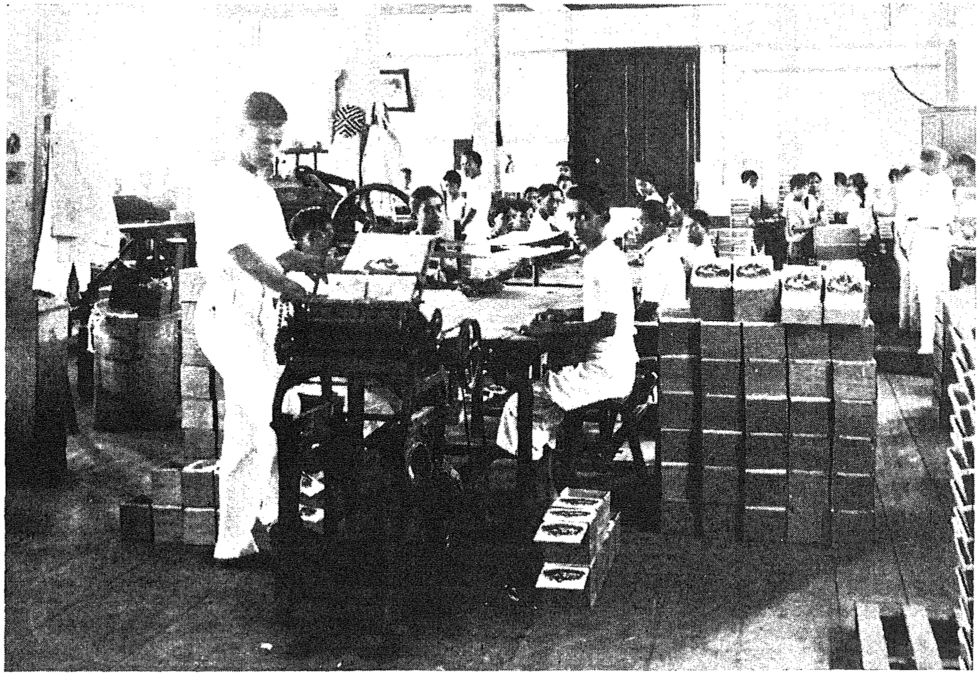
PLATE 17.



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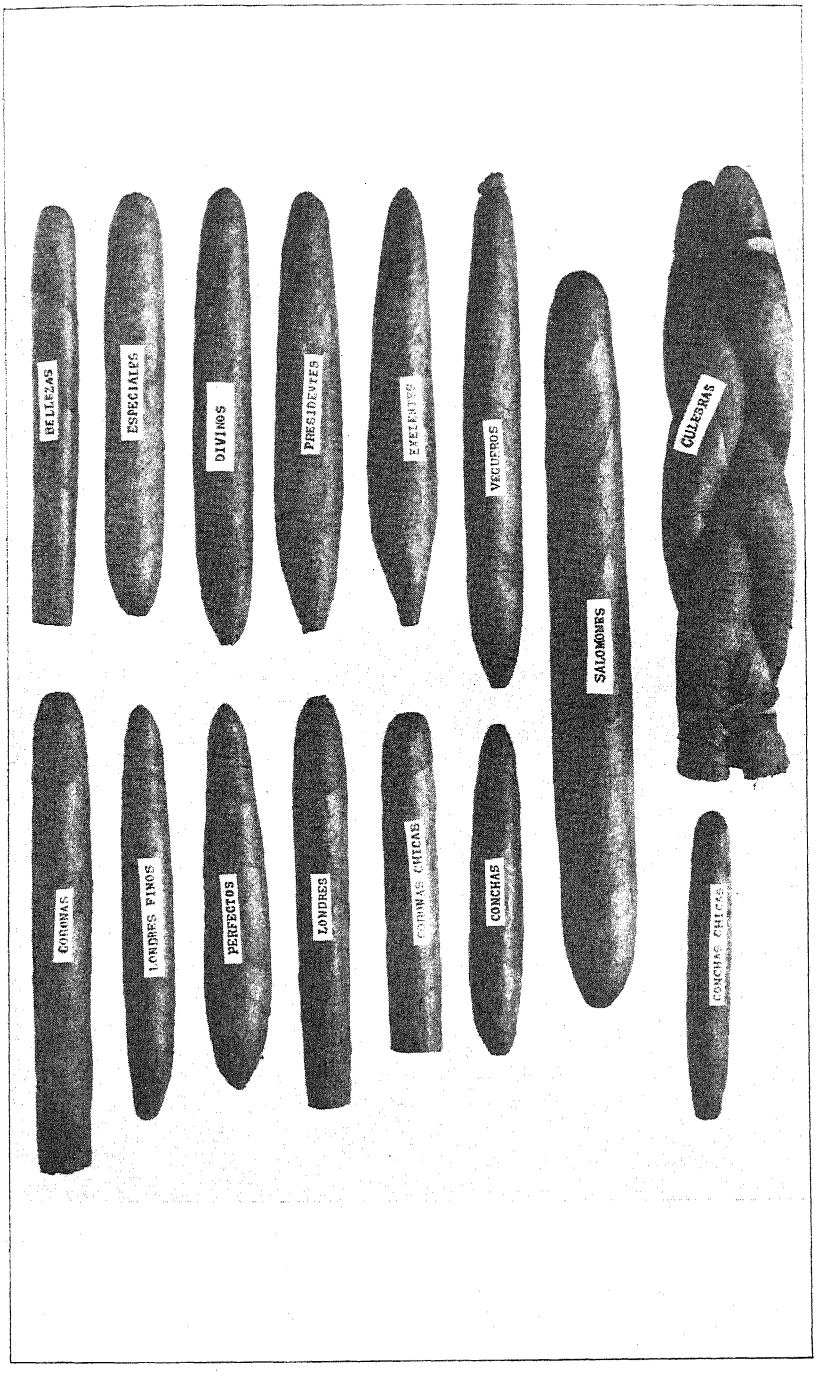
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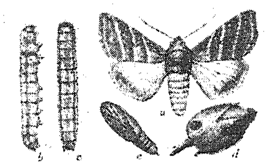
PLATE 19.



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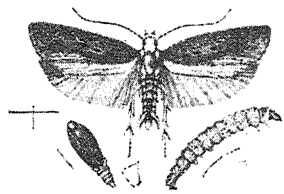

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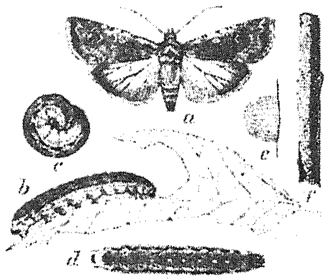

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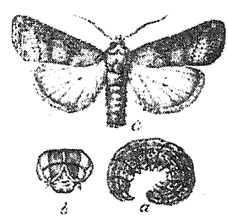

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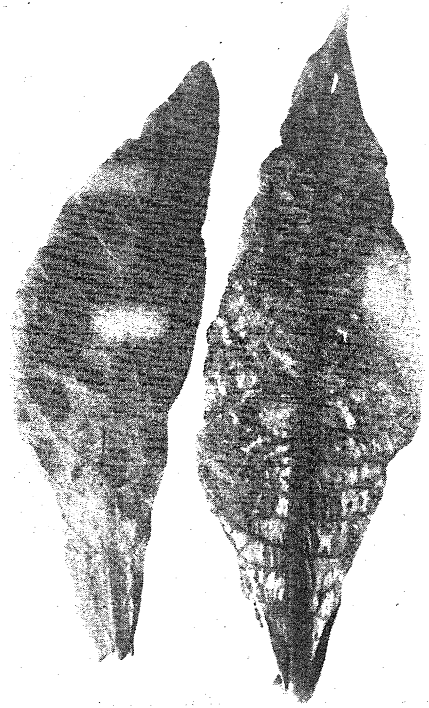
PLATE 20.



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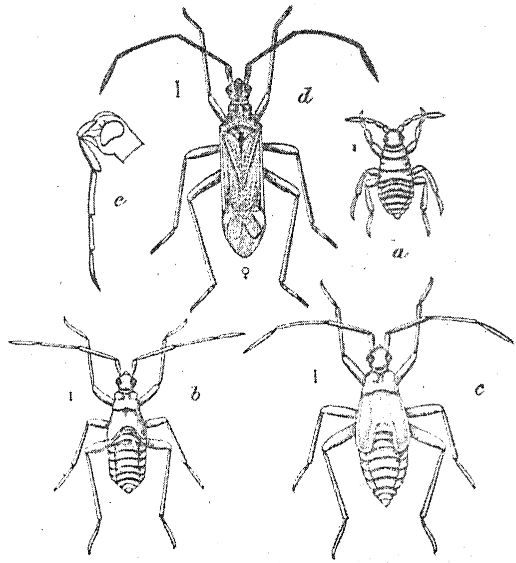

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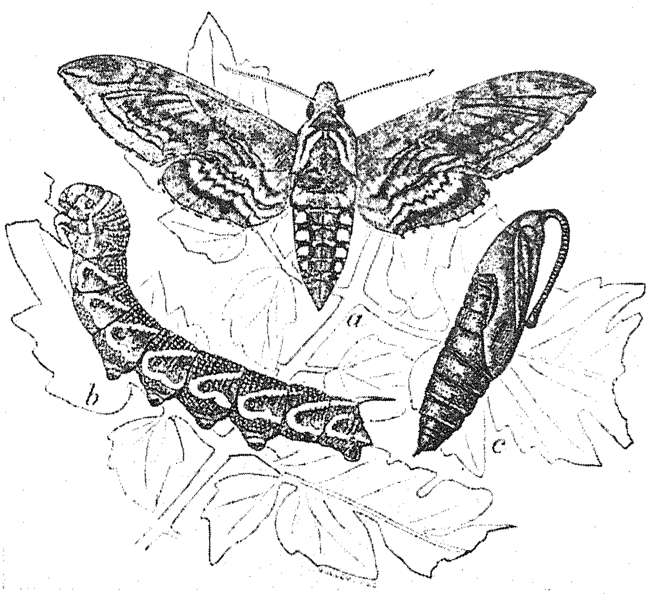

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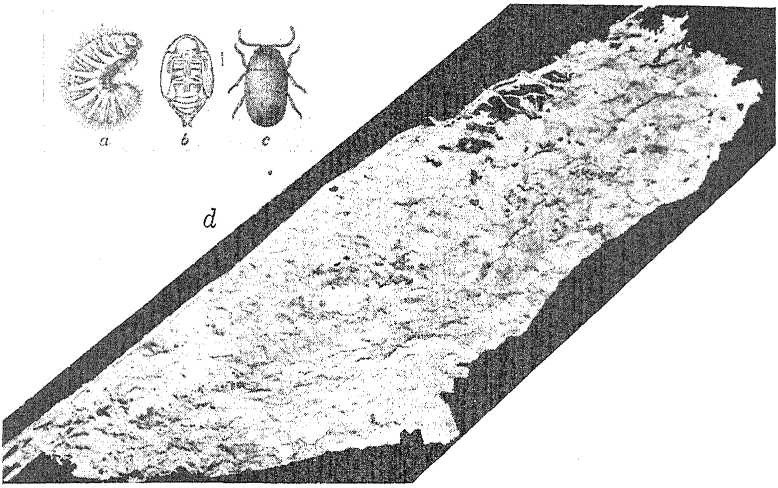

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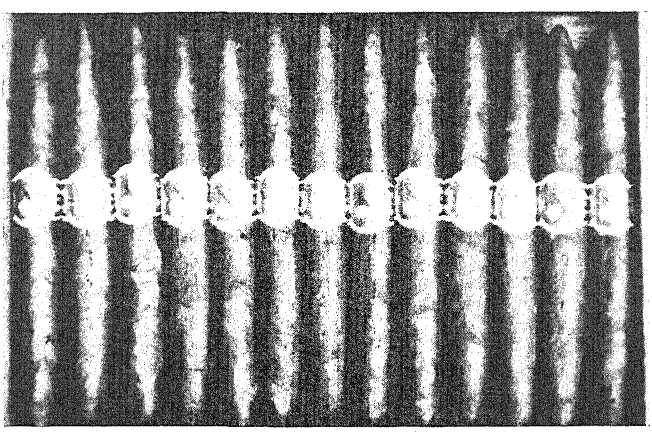

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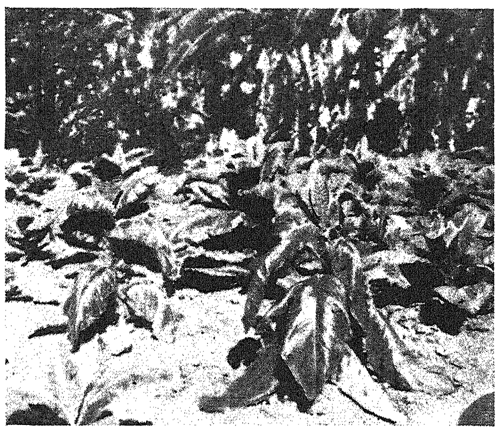

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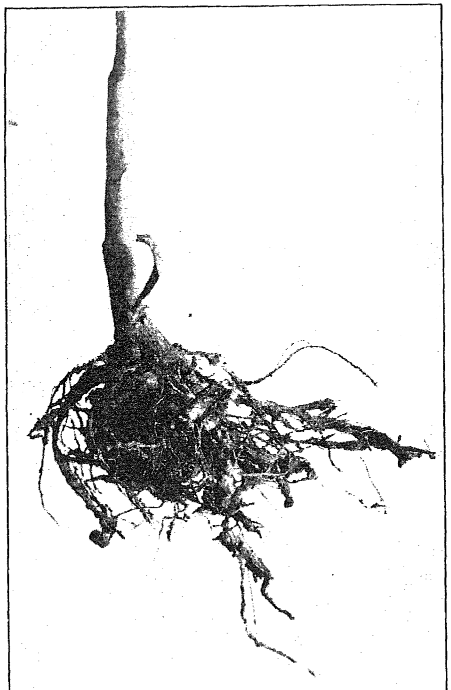

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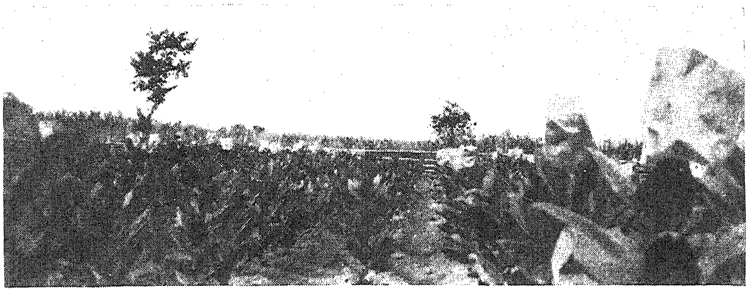

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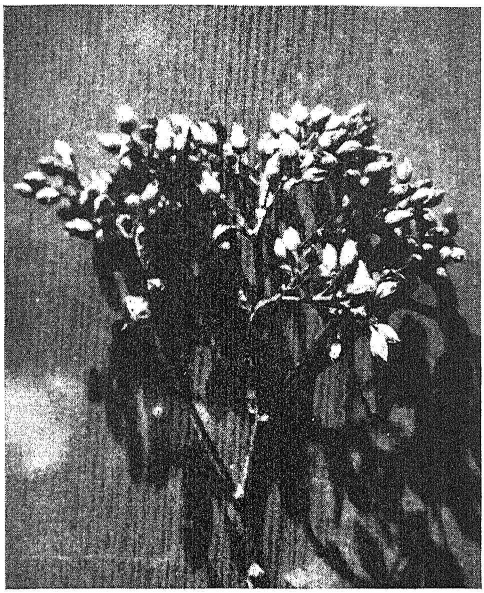

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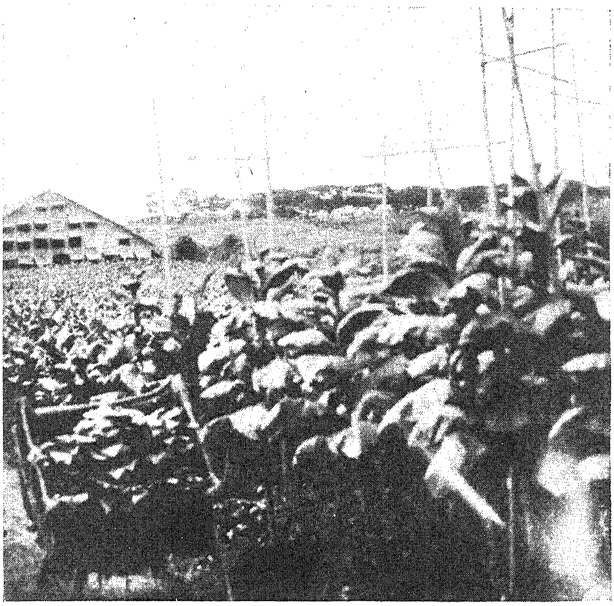

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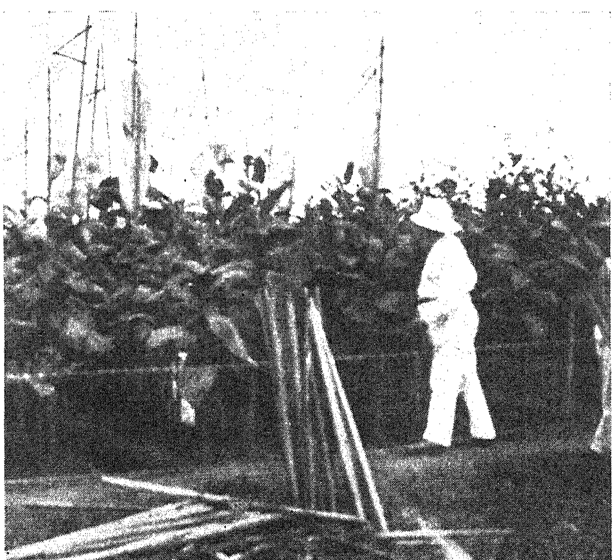

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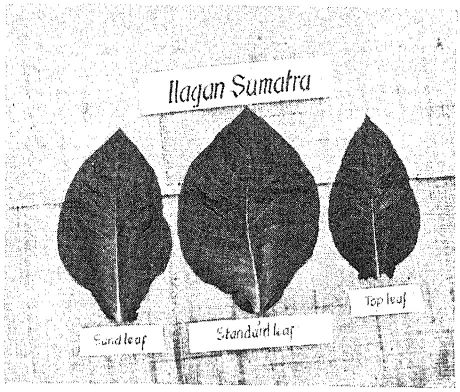
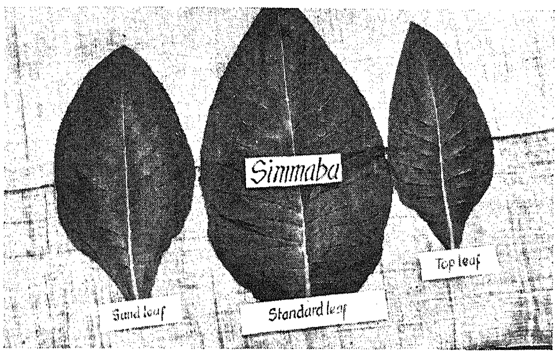
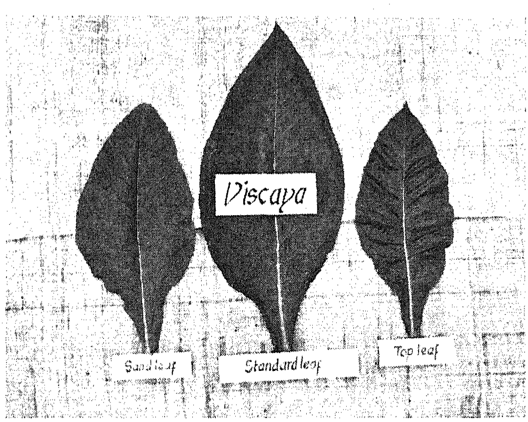
PLATE 28.


Ilagan Sumatra
Sand leaf
Standard leaf
Top leaf

1


Simmaba
Sand leaf
Standard leaf
Top leaf

2


Viscaya
Sand leaf
Standard leaf
Top leaf

3

PLATE 29.

A PROGRESS REPORT ON THE ACCLIMATIZATION OF CAULIFLOWERS, 1933-1934

By P. A. Rodrigo, P. S. Urbanes and P. Hernais

Of the Horticulture Section, Bureau of Plant Industry, Manila

FIVE PLATES

Heretofore, the culture of cauliflower, *Brassica oleracea* var. *botrytis* Hort., in the Philippines has been confined to high elevations particularly in Baguio and Trinidad Valley, Mountain Province. There have been some isolated claims that cauliflower has been grown in the past at Fort William McKinley and at Morong, Rizal. However, the fact still remains that cauliflower, is, up to this writing, a new plant to gardeners in the City of Manila and its vicinity. And, even in Baguio and Trinidad Valley, the culture of cauliflower is limited. There, it is generally grown from November to February and only a few gardeners raise it in spite of the high price it commands in the market. The reason is that it is difficult to insure the production of the "curd," the edible portion of the plant. Besides, gardeners there claim that cauliflower is a delicate crop to handle.

The main object of this study was to find some varieties of cauliflower that can be grown at sea level under tropical climates, and simultaneously to find some fertilizer treatments that may favor "curd" formation.

This preliminary report deals with the results of the 1933-1934 studies on cauliflower which were undertaken at the Central Experiment Station, San Andres, Manila,[1] and at the Lipa Coffee-Citrus Station,[2] Lipa, Batangas. The test was started in October, 1933 and completed in July, 1934.

MATERIALS AND METHODS

The seeds used in this study were imported from the United States, India, and Germany. The seeds from the last two countries were sent by some seed houses in those countries for trial planting here. In Table 1 are listed the varieties of cauliflower tried and the country of their origin.

[1] Manila is at sea level, while Lipa has an elevation of about 1,050 feet above sea level.

TABLE 1.—*Showing the varieties of cauliflower tested and the country of origin*

Variety name	Country of origin	Station where tested	Remarks
Henderson's Snowball	U. S. A.	Lipa Coffee-Citrus Station	No germination.
Primosnow	U. S. A.	do	Do.
Snow King	U. S. A.	do	Do.
Early Patna	India	Central Experiment Station and Lipa Coffee-Citrus Station.	Good germination.
Blumenkohl Juwel	Germany	Lipa Coffee-Citrus Station	Poor germination.
Blumenkohl Riesen	Germany	do	Do.

At the Central Experiment Station, three sets of planting were made; the first, early dry season planting (October to January); the second, late dry season planting (February to April); and the third, early rainy season planting (April to July). The first planting was treated with three kinds of fertilizers—the first series was fertilized with ammonium sulphate, the second series with ammonium sulphate and double superphosphate, and the third series with a complete fertilizer (8.3–16.7–8.3).

Table 3 gives the rate of application and the amount of available elements.

TABLE 2.—*Showing the fertilizers used, the rate of application and the amount of available elements from each*

Series No.	Name of fertilizer	Rate per hectare	Available elements per hectare	Formula
		Kilo	*Kilo*	
A	Ammonium sulphate	500	N 103	
B	Ammonium sulphate	500	N 103	
	Double superphosphate	530	P_2O_5 206.7	8.3–16.7–0
C	Ammonium sulphate	500	N 103	
	Double superphosphate	530	P_2O_5 206.7	8.3–16.7–8.3
	Sulphate of potash	210	K_2O 102.9	

The second and third plantings were fertilized with nitrophoska (15–15–18) at the rate of 700 kilos per hectare. When the plants have recovered from the effect of transplanting, they were twice dressed with ammonium sulphate at the rate of 80 kilos per hectare.

At the Lipa Coffee-Citrus Station, Lipa, Batangas, two sets of planting were made, early dry season planting and late dry

season planting. Both plantings were fertilized with only ammonium sulphate at the rate of 400 kilograms per hectare. The plants were also dressed twice with ammonium sulphate at the rate of 80 kilograms per hectare.

Cauliflower seedlings were raised in the same way as cabbage seedlings are produced. The seeds were first sown thickly in seed boxes and later pricked in beds for better development. The seedlings were transplanted in the garden when they were from four to five weeks old.

In all plantings, the seedlings were set in two-row beds, 60 centimeters between the rows and 50 centimeters between the plants. Before planting, about two handfuls of well rotted stable manure were put into the holes made for the reception of the plants. Where commercial fertilizers were used, such fertilizers were mixed with the stable manure which was previously put in the holes before planting.

Care of the plants.—The plants were weeded and cultivated regularly. Watering was done so as to keep the soil always moist, as it is done in a cabbage field. The plants were also sprayed regularly with lead arsenate spray (7 table spoonfuls [levelful] of lead arsenate to every petroleum canful of water) so as to prevent cabbage worms from destroying the cauliflower. Cabbage worms were observed rather in abundance particularly during the late dry season planting.

EXPERIMENTS AND RESULTS

Tests at the Central Experiment Station.—As already stated, three tests were conducted at the Central Experiment Station at San Andres, Manila. The variety Early Patna was the only one used in these tests.

The first test had a very good stand, and the formation of "curd" was comparatively uniform irrespective of the fertilizers used. In the second test, the stand of the plants was also good but the formation of the curd was rather irregular. The last test had a fair stand but rainfall was rather excessive just before the heading stage. As a result the heading was rather irregular, the curd small and, as a rule, was prone to "rice" early.

Tables 3, 4, 5, and 6 present the data of the first test, and Table 7 the second and third tests. Table 3 gives some data on the effect of the different kinds of fertilizers on the number of days to head, while Table 4, on the number of days to ma-

turity. Table 6 gives the average yield per plant as affected by the different fertilizers.

TABLE 3.—*Showing the number of days from sowing to heading as affected by different fertilizers*

Value	Frequency distribution		
	Series A	Series B	Series C
Day			
54	0	0	1
57	1	2	1
60	1	0	1
63	13	23	17
66	25	37	34
69	77	96	99
72	46	36	32
75	41	34	27
78	23	7	18
81	6	2	4
84	4	1	2
Total	237	238	236
Mean	71.32±0.204	69.59±0.161	70.09±0.199
Standard deviation	4.659±0.144	3.687±0.114	4.521±0.140
Coefficient of variability	65.32±2.752	52.98±2.048	64.53±2.704

TABLE 4.—*Showing the number of days from sowing to the harvesting of "curd"*

Value	Frequency distribution		
	Series A	Series B	Series C
Day			
64	0	0	1
67	1	0	1
70	2	7	1
73	4	3	1
76	16	22	23
79	91	121	119
82	50	47	48
85	39	24	20
88	13	7	12
91	11	7	7
94	6	0	2
97	3	0	1
100	1	0	0
Total	237	238	236
Mean	81.934±0.217	80.191±0.166	80.670±0.180
Standard deviation	4.941±0.154	3.783±0.117	4.092±0.127
Coefficient of variability	6.230±0.193	4.720±0.146	5.080±0.153

TABLE 5.—*Showing the number of days from the time the "curd" appeared to date of harvesting as affected by different fertilizers*

Value	Frequency distribution		
	Series A	Series B	Series C
Day			
6	4	12	6
9	115	119	125
12	92	86	90
15	23	18	11
18	1	2	3
21	1	1	1
24	1	0	0
Total	237	238	236
Mean	10.886±0.103	10.512±0.102	10.512±0.094
Standard deviation	2.340±0.073	2.328±0.072	2.136±0.066
Coefficient of variability	2.280±0.061	2.213±0.068	2.031±0.060

TABLE 6.—*Showing the weight per head of cauliflower as affected by different fertilizers*

Value	Frequency distribution		
	Series A	Series B	Series C
gram			
35	0	1	2
66	4	6	4
97	23	15	6
128	23	20	23
159	41	26	42
190	38	42	49
221	34	47	28
252	33	34	28
283	17	22	31
314	10	12	12
345	7	5	4
376	5	4	3
407	2	2	1
438	0	1	2
469	0	1	1
Total	237	238	236
Mean	202.71±3.18	212.01±3.20	211.39±3.15
Standard deviation	72.23±2.25	73.16±2.26	71.61±2.23
Coefficient of variability	35.63±1.24	34.47±1.18	33.80±1.16

TABLE 7.—*Showing the weight per head of cauliflower in late dry season and early rainy season plantings at the Central Experiment Station, Manila, 1934.*

Value	Frequency distribution	
	Late dry season planting (Feb.-Apr., 1934)	Early rainy season planting (Apr.-July, 1934)
gram		
35	3	28
66	12	27
97	21	18
128	18	8
159	12	4
190	17	5
221	12	5
252	6	0
283	3	2
314	0	0
345	--------	1
376	--------	1
407	--------	1
Total	104	100
Mean	147.84±4.12	99.17±5.12
Standard deviation	61.69±2.89	75.95±3.62
Coefficient of variability	41.70±2.26	76.50±5.35

Test at the Lipa Coffee-Citrus Station.—The first sowing was made in October, 1933. Unfortunately, the sowing was followed by an inclement weather and all the American varieties failed to germinate. Few seeds of the German varieties germinated and only a few of these were raised to transplanting size with some difficulty. The test, therefore, was mostly composed of the Indian variety, Early Patna. Few plants of the German varieties, Blumenkohl var. Juwel, and Blumenkohl var. Riesen reached maturity. These plants however, were not harvested; they were used for observation on cauliflower seed production. Table 8 presents some data on the yield of cauliflower in the two tests conducted at the Lipa Coffee-Citrus Station, Lipa, Batangas.

TABLE 8.—*Showing the weight per head of cauliflower in the early and late dry season plantings at the Lipa Coffee-Citrus Station*[1]

Value	Frequency distribution	
	Early dry season planting (Oct.–Jan.)	Late dry season planting (Feb.–Apr.)
gram		
35	1	1
66	4	1
97	8	5
128	10	4
159	16	5
190	15	7
221	21	10
252	26	5
283	24	7
314	28	2
345	26	7
376	11	7
407	7	5
438	6	5
469	1	1
500	6	0
531	0	0
562	0	0
Total	210	72
Mean	270.60±4.72	264.40±8.71
Standard deviation	97.96±3.03	108.50±6.10
Coefficient of variability	36.20±1.37	41.00±2.65

[1] The comparatively high yield was partly due to the over maturity of some of the heads when harvested.

Some observations on diseases.—During the formation of head or "curd," a certain disease was noticed which caused the discoloration of the "curd." Only a few plants of the first planting in Manila were affected by the disease; in the second and third plantings, more were affected. The disease seemed to be more serious in Lipa than in Manila. According to Dr. F. Clara of the Pathology Section of the Bureau of Plant Industry, the disease is caused by two organisms—one is a fungus and the other is a bacterium.

The disease, because of the nature of the infected curd, may be called cauliflower curd rot. The diseased portion, at first, appears as a tiny spot, brownish in color. This rotting advances rather rapidly in a more or less regular front over the curd and in advanced cases renders the curd useless for culinary purposes.

Some observations on flowering.—Some plants at the maturity of the head or "curd" were allowed to remain uncut. The object was to find the possibility of producing seeds of cauliflower under local conditions. The study which is still in progress was conducted at the Central Experiment Station, and at the Lipa Coffee-Citrus Station, Lipa, Batangas.

Most of the plants that were allowed to flower produced pods (see Plate 2) but these failed to produce any seed. In Lipa, however, two seeds were obtained; these were planted at the Central Experiment Station in Manila. At the present writing, the two plants were in flower. The result of this test together with a detailed study of the flower and the possible causes of the failure of the pods to produce seeds will be reported in a separate paper at a later date.

Propagation of cauliflower by slips.—The cauliflower is commercially propagated by seed. Upon harvesting the first crop, a few stubs were left by accident in the garden undisturbed after cutting the heads. These produced slips at their bases after a couple of days which looked like regular cauliflower seedlings. Upon examination it was found that some of these slips produced roots. Two small plots were planted with these cauliflower slips; one plot with rooted slips, and the other with slips without roots. Both plots gave 100 per cent stand and the plants attained normal size but they produced small heads, perhaps, because of the late season. Besides, most of the heads were attacked by some diseases which caused them to rot.

DISCUSSION OF RESULTS

The result of this study was significant; it has brought new information that should prove very interesting and valuable to gardeners in the lowland.

Tests at the Central Experiment Station.—The first test which was considered as the early dry season planting (sown on October 24, 1933, and transplanted on November 24, 1933) produced a normal crop of cauliflower comparable to those raised in Trinidad Valley, Mountain Province. The plants began to form head or "curd," in the average, from 69.59 ± 0.161 to 71.32 ± 0.204 days after sowing. The first head formation was observed 54 days after sowing the seed and the last was noticed after 84 days (see Table 3). The first head was harvested 64 days after sowing and the last head, after 100 days.

In an attempt to find some fertilizer treatments that would favor head formation, three series of plots (A, B, and C) were

run. Series A was fertilized with nitrogen alone, series B with nitrogen and phosphorous; and series C with nitrogen, phosphorous, and potash. The amount of nitrogen in all series was the same and so with phosphorous in the two series receiving it (see Table 2). As shown in Table 6, the kind of fertilizer applied practically did not affect head formation; the plants receiving different fertilizer treatments produced heads. It may be added in this connection that no plant failing to produce head in any series was noticed except those whose terminal buds were destroyed by worms. There was, however, some slight differences in weight per head in favor of series B (fertilized with nitrogen and phosphorous), and series C (fertilized with nitrogen, phosphorous and potash). Perhaps, the soil was only slightly deficient in phosphorous and potash. The average weight per head in Series A was 202.71 ± 3.18 grams; that in series B was 212.01 ± 3.20 grams; and that in series C was 211.39 ± 3.15 grams. There was practically no difference between Series B and C as to the average weight of head per plant (see Table 6).

The other two plantings at the Central Experiment Station (late dry season and early rainy season) did not give results as good as the early dry season planting. While the source of the nitrogen in the last two plantings was different from the early dry season planting, the difference in yield could not be attributed to it. For even in the last two tests where the fertilizers used were the same, the early rainy season planting gave less average yield. The average yield per plant was 211.39 ± 3.15 grams for the early dry season planting; 147.84 ± 4.12 grams for the late dry season planting; and 99.17 ± 5.12 for the early rainy season planting (see Tables 6 and 7). The difference between the different plantings were all mathematically significant. It was also observed that in the last two plantings, the heads even when not yet fully developed, were prone to "rice," particularly in the last planting. The quality of the product in the last two plantings was inferior to the first planting.

The difference in yield must have been mainly due to the climatic conditions particularly the temperature, and in the last planting, also the excessive rainfall. For according to Thompson,[2] the "cauliflower thrives best in a cool, moist climate," and

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[2] Thompson, H. C. Vegetable crops. ix + 560 p. 60 fig. New York: McGraw-Hill Book Company (1931).

that its "head will not develop well in hot weather." In the early dry season planting (last part of October to early part of January) the temperature was low, being the coolest part of the year but during the late dry season planting (February to April) the weather was hot and dry. During the last planting (April to early part of July) the weather was still hot and the plants were further affected by the torrential rains in June and July.

Tests at the Lipa Coffee-Citrus Station.—Both the early and late dry season plantings produced normal crops of cauliflower (Early Patna variety). The few plants of the two German varieties, Juwel and Riesen, also produced normal heads. In the case of the Early Patna variety the average yield per plant was 270.60 ± 4.72 grams for the early dry season crop and 264.40 ± 8.71 grams for the late dry season (see Table 8). Like in the Central Experiment Station, the early planting produced more than the late dry season crop. However, in Lipa, the difference was not considered mathematically significant. The reason was perhaps, due to the slight change in temperature because of the high elevation (1,050 ft.) of the place.

Some observations on diseases.—While these were the first attempt to grow cauliflower at the Central Experiment Station, and at the Lipa Coffee-Citrus Station, it was surprising to observe some diseases attacking the young heads. The disease caused the rotting of the head. At first it appeared as a tiny brownish speck but which advanced quite rapidly in a more or less regular front. The infested head became blackish brown. The diseases reduced the value of the curd and in severe cases rendered it unfit for consumption.

This disease might become a limiting factor in cauliflower production here if no control measure could be evolved.

Some observations in flowering.—An attempt was made to let some of the plants to produce flowers and possibly seeds. The plants the heads of which were not cut produced flowers and pods (See Figs. 4 and 5) but with the exception of a plant of the variety Early Patna at the Lipa Coffee-Citrus Station which produced two seeds, all the plants failed to seed. The plants produced a good crop of pods but they did not produce seeds. Upon examination it was found that there was scarcity of pollen grains in most of the plants examined.

The use of slips for planting.—Cauliflower stubs that were not pulled up produced some slips. These were tested for their value as planting materials. The trial although very limited showed

some possibility that merits further study. The cauliflower slips if found suitable for planting will be handy for home gardens, where small but continuous plantings may be desired.

SUMMARY OF CONCLUSIONS

1. This report presents the results of one year study on the acclimatization and cultural treatment of cauliflower. This was the first successful attempt in the Philippines to grow cauliflower at sea level and at elevations lower than Baguio and the Trinidad Valley, Mountain Province. The variety that was found successful came from Calcutta, India, and its variety name is Early Patna.

2. Both the trial tests at the Central Experiment Station, Manila (sea level) and at the Lipa Coffee-Citrus Station, Lipa, Batangas (1,050 feet above sea level) produced normal crops of cauliflower. The highest average yield per plant in Manila was 212.01 $\pm$ 3.20 grams while in Lipa, it was 270.60 $\pm$ 4.72 grams. Also those planted during the cool months of October to January produced heavier heads than those planted later in the season.

3. The variety Early Patna began to form head, in the average of 69.59 $\pm$ 0.161 to 71.32 $\pm$ 0.204 days after sowing, and the heads were ready to be harvested in the average of 80.19 $\pm$ 0.166 to 81.33 $\pm$ 0.217 days after sowing. In other words, the Early Patna cauliflower matured in 80 days after sowing the seed when planted at sea level during the cool months of the year.

4. The plants which were fertilized with a complete fertilizer and a combination of nitrogen and phosphorous had the tendency to mature earlier and to produce heavier heads than those fertilized with nitrogen alone.

5. Other varieties that produced head besides the Early Patna at the Lipa Coffee-Citrus Station were two German varieties, Blümenkohl Juwel and Blumenkohl Riesen.

6. Several plants of the Early Patna, Blumenkohl Juwel and Blumenkohl Riesen varieties produced flowers and pods but failed to produce seeds except a plant of the Early Patna in Lipa which produced two good seeds. Many flowers produced in Manila when examined were found to have few or no pollen grains at all.

7. A preliminary study on the use of slips for planting purposes showed some possibility for such use in home gardens where small but more or less continuous plantings are desired. The plants were big and vigorous but the head were small perhaps because of the hot weather.

ILLUSTRATIONS

PLATE 1

A cauliflower plantation at the Central Experiment Station, San Andres, Manila. The cauliflower plots are those marked (X). Note the size of the plants and their narrow leaves as compared with the cabbage plants in between.

PLATE 2

Showing some cauliflower heads or "curd" (Early Patna). These represent the first harvest at the Central Experiment Station, San Andres, Manila.

PLATE 3

A cauliflower head showing its well advance "rice" stage. Note the flower stalks.

PLATE 4

A cauliflower inflorescence with some flowers about to open.

PLATE 5

Some cauliflower plants in full bloom. Note the numerous flowers in fig. 1 and the developing pods in figs. 1 and 2.

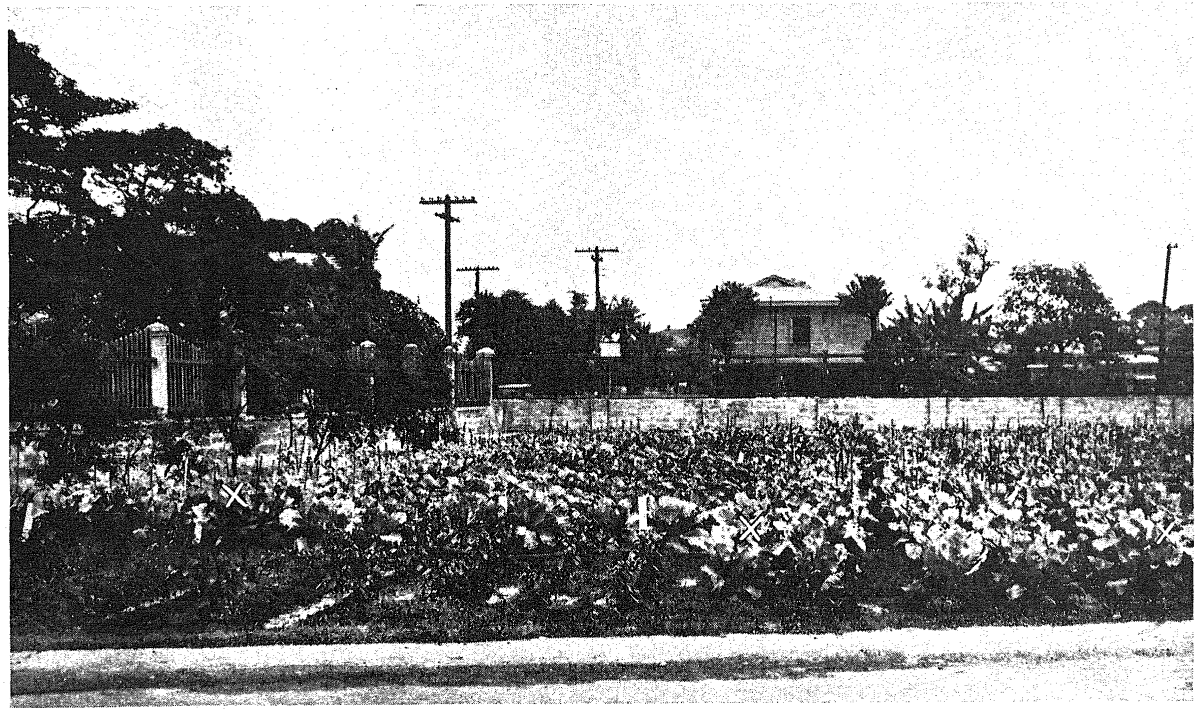


PLATE 1.

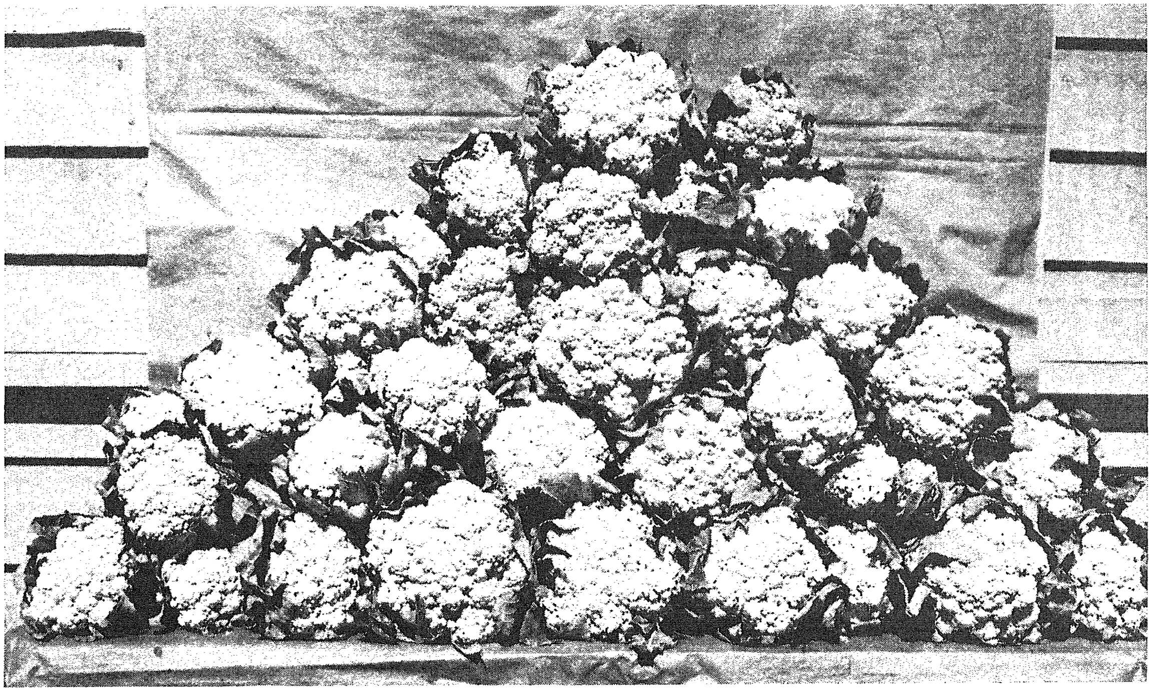


PLATE 2.

PLATE 3.

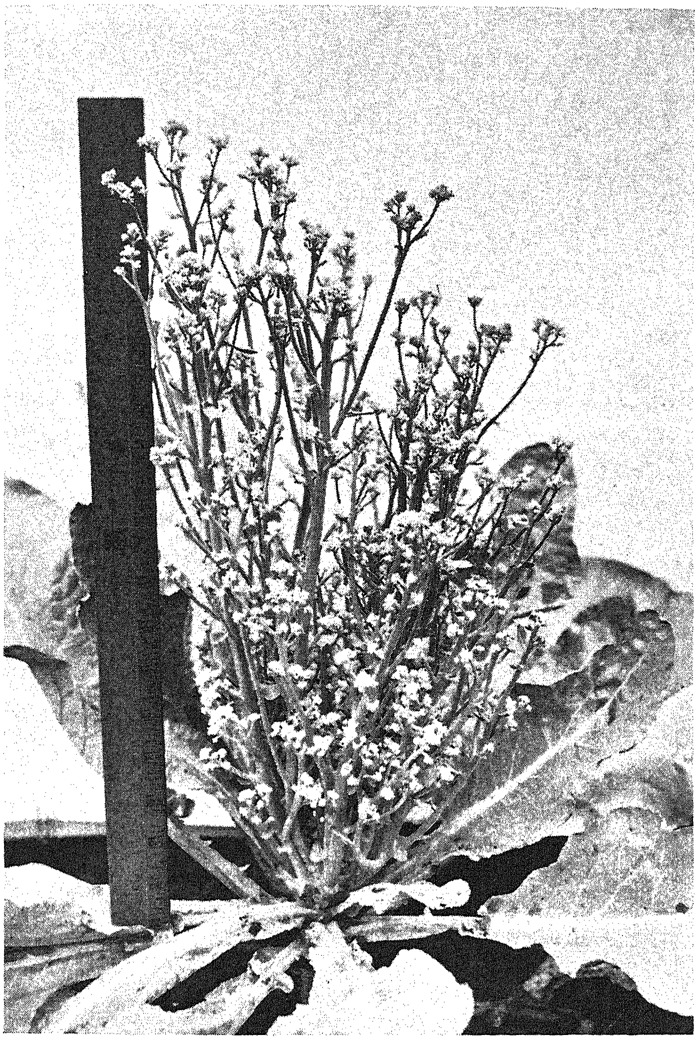
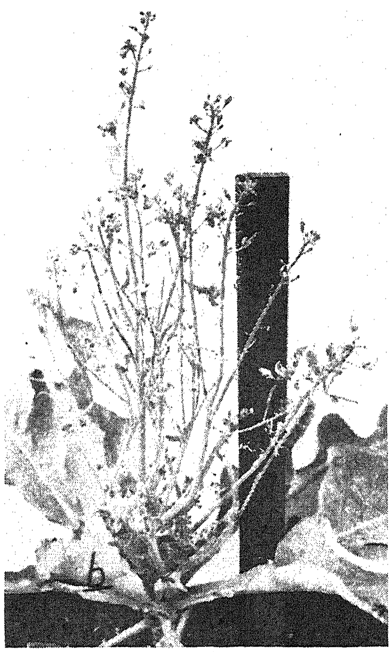


PLATE 4.

1



2

PLATE 5.

THE RELATION OF FRUITING TO VEGETATIVE GROWTH CHARACTERS IN CARABAO MANGO, *MANGIFERA INDICA* L.

By F. G. GALANG and FELIX D. LAZO

Of the Horticulture Section, Bureau of Plant Industry, Manila

TWO TEXT FIGURES

Considerable interest has been manifested in the relation between the fruit bud formation and the vegetative growth of the plant. But so far not much data upon the possible relationship have been obtained, except on a few temperate fruit trees. To improve the yield of a tree it is necessary to find out the relation existing between its various parts and its fruiting ability, that is, if certain distinguishable growth characters are associated with the production of fruits. To accomplish this the vegetative growth of the tree should be thoroughly studied and measured. To know the desirable qualities and the vegetative growths which influence the fruiting of a tree is a safe criterion to be followed in improving that tree either by breeding or by cultural methods. For according to Collins (1) nearly all successful breeding has been made possible by the fact that correlations exist. And if the study of correlations has appeared to have little bearing on plant breeding, it must be that we have studied the wrong characters or studied them in the wrong way, he said. In formulating the ideal type, however, a distinction is also to be made between characters which do not bear the qualities sought, but are only supposed to have some fundamental bearing with their development. And before making distinctions of these characters it is essential to ascertain first the relative merits of the mutually exclusive characters of the different parts—leaves, stems, and roots—of the plant, and whether the bearing quality is really dependent upon a particular character or a combination of such characters. The immediate objective of the present study, therefore, was to determine the relationship between the growth characters of the shoot and the fruiting of the Carabao mango, *Mangifera indica* L., and, if correlation exists, then growth measurements are in order so as to enable us to point out definitely such desirable characters.

Available literature pertaining to this subject is scant. But according to Robert (2) an increase in diameter of the wood of apple trees due to the laying down of reserve materials is favorable to blossom formation, and shoots and spurs having intermediate length are where the fruit buds are most readily formed, while the shortest spurs rarely produced fruit buds, and many of the longest spurs had terminal leaf buds. Moreover, fruitfulness was associated with the thickness of the shoots, or regular bearing was related to wood growth. Kraus and Kraybill (3) obtained an identical result on tomato plant. Crow and Edit (4) suggested the possibility of the growth in diameter as an index of flower bud formation. Roberts, again, found that when the overvegetative apple tree produced growth with a thick diameter (in relation to length of growth) it became fruitful. Gardner (5) believes that there is a close correlation between increase in trunk circumference at any period and the leaf area possessed by the tree at that particular time.

As regards the growing of the leaves, Gourley (6) has suggested that large leaf surface is associated with fruit bud formation. Magness (7) said that the fruit-bud initiation of the apple will not take place, and fruit bud will not form in most varieties in the absence of a fair amount of leaf-area in the tree. And the leaf area in one part of the tree will usually not supply food material to the buds in another part to the extent necessary to cause them to become fruit buds. Roberts (2) found that the longer the spurs were the more number of leaves there were and the leaf area was greatly increased. And that biennial bearing was related to spur growth and was more so during the off season, and regular bearing was related to wood-growth and there was more growth in the regular bearing tree than on the biennial bearing tree. This again proved that fruitfulness was better on trees which made an intermediate growth. The same author reported that from 48.8 to 54.3 per cent of the shoots with larger leaves flowered against 0.5 to 4.1 per cent of the shoots having small terminal leaves. On the other hand, Kraybill et al. (8) reported that the leaf area in square inches per spur of the apple tree was highest on the nonfruiting spurs of the nitrogen plot, lowest on the fruiting spurs on the sod plot, and approximately equal and intermediate on the nonfruiting spurs of the sod plot and the fruiting spurs of the nitrogen plot. However, the bearing spurs of the sod plot, which formed no fruit buds whatever, uniformly showed the smallest leaf area.

From his finding, therefore, it appears that there is, in general, a tendency to produce more flowers as the leaf area increases. Rapidly growing plants rarely form many flower buds because the food is used in growth as fast as they are formed, and the size of the leaves depends much on the water supply during their formation while the growth of the stem and roots depends upon the number of leaves, according to Goff (9). There is a correlation between the number of leaves and the development of the fruit. A certain number of leaves are necessary for the proper development of the fruit and the greater the leaf area per fruit, the greater the total size of the fruit produced, although the increase in size of the fruit is not in proportion to the increase in foliage according to Magness, et. al (10). Hayes and Garber (11) pointed out that the yield of plant, particularly of wheat and oats, is the result of many growth factors, but in general no one character is closely associated with yield, at least to such an extent as to be of selection value in picking out high yielding strains.

MATERIALS AND METHODS

The materials used in this study consisted of seedling and vegetatively grown Carabao mango trees of various fruiting ages growing in Bataan and Pampanga. The districts covered by this study are good representative mango districts having a distinct dry and rainy season favorable to the fruiting of mango. The Carabao mango is the most important mango variety grown in the Philippines; it is reputed to surpass the flavor and quality of all the other varieties found under cultivation here and elsewhere. Both heavy-bearing and light-bearing trees under similar soil and climatic conditions were studied, and some old non-bearing trees were observe as check. The parts included in the study were the length and diameter of the bearing and non-bearing trees were observed as check. The parts included growths, and the dimension and the number of their leaves. Inasmuch as the flowers of the mango are in the majority of cases produced on the previous season's growth, the present observations have been confined to this portion of the branches.

In all cases the length of the portion of the twigs studied was taken from the tip to the basal end and the diameter at the middle portion of each shoot (Fig. 1). Both length and width measurements of leaves were taken from a number of representative twigs. The petioles were excluded from the measurements

(Fig. 2). The leaves of all the twigs measured were counted and numbered 137,788 in all. Measurements were taken from 6,628 bearing and 8,716 non-bearing terminal and lateral shoots and 5,830 leaves of 34 bearing trees and 10 non-bearing robust and unthrifty trees. Terminal as well as lateral shoots were studied. Twigs and leaves on four quadrants of the trees—north, south, east, and west—were measured and counted in order to eliminate the possible influence of light and wind velocity, if any. Twigs that have fruited or flowered were considered bearing, and all others non-bearing. The shoots were classified as terminal if they originated from terminal buds and lateral if from the axillary buds.

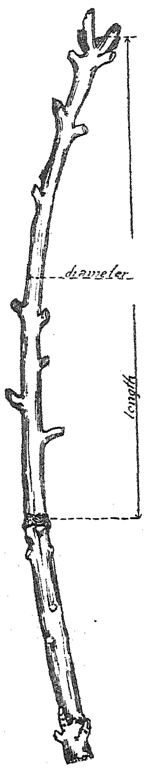


FIG. 1.

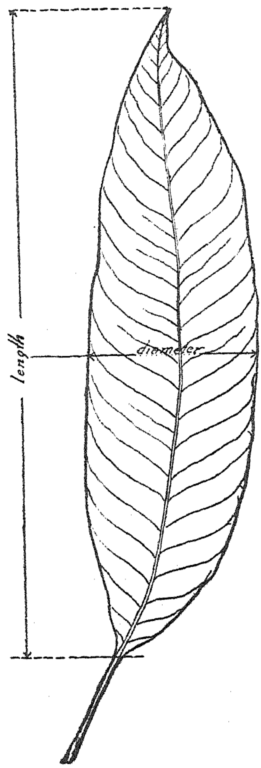


FIG. 2.

The mean and the difference of the growths of the fruiting and non-fruiting shoots were calculated and determined by using Babcock and Clausen formulæ. The results of these computations are presented in Tables 1, 2, and 3.

DISCUSSION OF RESULTS

The materials used were of different strains some of which were grown vegetatively and others from seedling trees, and the observations covered only one fruiting season. If the trees studied were originated from a pure and vegetatively grown strain a reliable measure of the behavior of the trees may be expected. But there were no such trees available for study. However, the results obtained are believed sufficiently interesting

to warrant their publication. They may serve as guide in the proper cultural treatment and care of the Carabao mango tree. The results show among other things that there is a positive difference between the length and diameter of the shoots, and the number and area of the leaves of the bearing and non-bearing Carabao mango trees. The fruiting ability of the Carabao mango tree, therefore, seems to be dependent upon the growth of its twigs and leaves.

Considering the bearing tree as a whole, the bearing terminal as well as the lateral twigs were longer and greater in diameter than the non-bearing twigs. There were slightly more but smaller, leaves on the bearing than on the nonbearing shoots (see Table 1).

From Table 2 it is interesting to note that the terminal as well as the lateral twigs of the nonbearing robust trees were longer, larger and had smaller and more leaves than the twigs of the bearing trees. On the other hand, Table 3 shows that the growth characters of the nonbearing unthrifty trees, also at bearing age, were much less than those of the bearing trees both in length and in diameter of the twigs, and the number and area of the leaves. In this connection it may be stated that a mango twig, in order to have the greatest chance of producing flowers, has to attain a length of 14.23 ± 0.0113 cm. and a diameter of 6.25 ± 0.0021 mm., and with a total of 10.47 ± 0.0060 leaves measuring 94.67 ± 0.2013 sq. cm. each. Deviations from these figures, either downward or upward, as may be seen from Tables 1 to 3, seem to lessen in a direct proportion the chance for the twig to flower. Even taking into consideration the twigs at the different quadrants of the bearing and nonbearing trees to find if these growth characters are influenced either by the wind or morning and afternoon sun, it has been observed that the same relationship exists as shown in Tables 4 to 6. For instance, Table 4 shows that the bearing terminal as well as the lateral twigs of the bearing trees in all directions exhibited longer, larger and slightly more leaves but generally less total leaf area than the nonbearing twigs; Table 5, shows that the twigs of the nonbearing robust trees were longer, bigger and contain more leaves and of greater total leaf area than the bearing twigs; and Table 6, shows that the twigs of the nonbearing unthrifty trees were shorter and generally smaller in diameter and with less total number and area of leaves, than bearing twigs.

CONCLUSIONS

From the observations made there seems to be little doubt that the growth characters of the shoots and the number and area of the leaves of the Carabao mango tree are associated with its fruiting ability. The following conclusions may be deduced from the foregoing data:

1. There is a relation between the length and diameter of the twigs with fruiting. It is apparent that in the case of the nonbearing robust trees in this test there were an abundance of vegetative growths of the twigs—length and diameter—compared with the bearing trees. On the other hand, the average length and diameter of the twigs were less on the nonbearing unthrifty trees than on the bearing trees, except in a few cases where the diameter was a little more than those of the bearing twigs.

2. There is a relation between the leaf area and the number of leaves with fruiting. As the number of leaves increases, each with a less leaf area, the less fruitful the tree becomes as in the case of the nonbearing robust trees. On the other hand, as they diminish both in number and dimension as in the case of the non-bearing unthrifty trees the less the trees become fruitful.

3. In the case of the bearing trees the average length and diameter of the bearing twigs were greater than those of the nonbearing twigs. And also there were more leaves but with less leaf area.

TABLE I.—*Showing the difference between the bearing and the nonbearing twigs*

Parts	Bearing trees			
	Mean of bearing twigs	Mean of nonbearing twigs	Difference	Significance (5×P.E.D.)
Terminal shoots:				
Length of twigs in cm.	14.23±0.0113	12.56±0.0101	1.67±0.0151	Significant.
Diameter of twigs in mm.	6.25±0.0021	5.87±0.0024	0.38±0.0031	Do.
Number of leaves	10.47±0.0060	10.16±0.0060	0.31±0.0084	Do.
Area of leaves in sq. cm.	94.67±0.2013	99.99±0.3074	5.32±0.3674	Do.
Lateral shoots:				
Length of twigs in cm.	14.62±0.0094	13.88±0.0099	0.74±0.0136	Do.
Diameter of twigs in mm.	5.35±0.0020	5.16±0.0030	0.19±0.0036	Do.
Number of leaves	7.30±0.0059	7.19±0.0071	0.11±0.0092	Do.
Area of leaves in sq. cm.	84.59±0.0651	86.15±0.3172	1.56±0.3237	Doubtful.

TABLE II.—*Showing the difference between bearing twigs and twigs of nonbearing robust trees*

Parts	Mean of bearing twigs	Mean of twigs of nonbearing robust trees	Difference	Significance (5×P.E.D.)
Terminal shoots:				
Length of twigs in cm.	14.23±0.0113	19.14±0.1804	4.91±0.1807	Significant.
Diameter of twigs in mm.	6.25±0.0021	7.30±0.0099	1.05±0.0101	Do.
Number of leaves	10.47±0.0060	14.01±0.0270	3.54±0.0276	Do.
Area of leaves in sq. cm.	94.67±0.2013	88.98±0.1663	5.69±0.2611	Do.
Lateral shoots:				
Length of twigs in cm.	14.62±0.0094	23.47±0.0484	8.85±0.0493	Do.
Diameter of twigs in mm.	5.35±0.0020	6.97±0.0442	1.62±0.0442	Do.
Number of leaves	7.30±0.0059	10.63±0.1140	3.33±0.1141	Do.
Area of leaves in sq. cm.	84.59±0.0651	74.67±0.2082	9.92±0.2181	Do.

TABLE III.—*Showing the difference between bearing twigs and twigs of nonbearing unthrifty trees.*

Parts	Mean of bearing twigs	Mean of twigs of nonbearing unthrifty trees	Difference	Significance (5×P.E.D.)
Terminal shoots:				
Length of twigs in cm.	14.23±0.0113	7.05±0.0311	7.18±0.0330	Significant.
Diameter of twigs in mm.	6.25±0.0021	6.11±0.0248	0.14±0.0248	Do.
Number of leaves	10.47±0.0060	9.94±0.0217	0.53±0.0225	Do.
Area of leaves in sq. cm.	94.67±0.2013	46.88±0.1503	47.79±0.2512	Do.
Lateral shoots:				
Length of twigs in cm.	14.62±0.0094	8.43±0.0343	6.19±0.0355	Do.
Diameter of twigs in mm.	5.35±0.0020	5.37±0.0068	0.02±0.0070	Insignificant.
Number of leaves	7.30±0.0059	6.95±0.0234	0.35±0.0241	Significant.
Area of leaves in sq. cm.	84.59±0.0651	44.99±0.1393	39.60±0.1537	Do.

TABLE IV.—*Showing difference by direction between bearing and nonbearing twigs of bearing trees*

Parts	Bearing trees			
	Mean of bearing twigs	Mean of nonbearing twigs	Difference	Significance) (5×P.E.D.
Terminal shoots:				
Length of twigs in cm.	14.18±0.0467	12.27±0.0429	1.91±0.0634	Significant.
Diameter of twigs in mm.	6.28±0.0087	5.95±0.0366	0.33±0.0376	Do.
Number of leaves	10.38±0.0250	10.03±0.0253	0.35±0.0355	Do.
Area of leaves in sq. cm.	91.53±0.0892	98.22±1.1713	6.69±1.1720	Do.
Lateral shoots:				
Length of twigs in cm.	14.61±0.0391	13.94±0.0412	0.67±0.0568	Do.
Diameter of twigs in mm.	5.53±0.0061	5.36±0.0138	0.17±0.0150	Do.
Number of leaves	7.22±0.0198	7.05±0.0204	0.17±0.0284	Do.
Area of leaves in sq. cm.	86.08±0.1051	83.36±0.6345	2.72±0.6431	Doubtful.
North terminal shoots:				
Length of twigs in cm.	14.21±0.0402	12.10±0.0362	2.11±0.0540	Significant.
Diameter of twigs in mm.	6.28±0.0074	5.94±0.0069	0.34±0.0101	Do.
Number of leaves	10.53±0.0239	9.88±0.0199	0.65±0.0311	Do.
Area of leaves in sq. cm.	90.03±0.0425	90.36±0.6008	0.33±0.6023	Insignificant.
North lateral shoots:				
Length of twigs in cm.	14.73±0.0322	13.41±0.0401	1.32±0.0514	Significant.
Diameter of twigs in mm.	5.56±0.0074	5.33±0.0076	0.23±0.0106	Do.
Number of leaves	7.39±0.0228	6.78±0.0159	0.61±0.0277	Do.
Area of leaves in sq. cm.	88.03±0.0831	89.44±1.3259	1.41±1.3285	Insignificant.
West terminal shoots:				
Length of twigs in cm.	14.25±0.0368	12.75±0.0364	1.50±0.0517	Significant.
Diameter of twigs in mm.	6.30±0.0389	5.74±0.0071	0.56±0.0395	Do.
Number of leaves	10.17±0.0243	10.26±0.0241	0.09±0.0342	Insignificant.
Area of leaves in sq. cm.	94.85±0.0883	113.95±1.0850	19.10±1.0885	Significant.
West lateral shoots:				
Length of twigs in cm.	15.21±0.0318	13.79±0.0263	1.42±0.0412	Do.
Diameter of twigs in mm.	5.24±0.0090	5.24±0.0053	--------------	Do.
Number of leaves	7.27±0.0191	7.11±0.0232	0.16±0.0300	Significant.
Area of leaves in sq. cm.	86.40±0.0403	88.82±1.1353	2.43±1.1360	Insignificant.
South terminal shoots:				
Length of twigs in cm.	14.29±0.0344	13.51±0.0358	0.78±0.0496	Significant.
Diameter of twigs in mm.	6.38±0.0097	6.40±0.0096	0.02±0.0136	Insignificant.
Number of leaves	10.68±0.0243	10.67±0.0248	0.01±0.0347	Do.
Area of leaves in sq. cm.	100.45±0.1077	104.49±1.8609	4.04±1.8095	Do.
South lateral shoots:				
Length of twigs in cm.	14.75±0.0333	14.59±0.0318	0.16±0.0460	Doubtful.
Diameter of twigs in mm.	5.47±0.0066	5.06±0.0058	0.41±0.0087	Significant.
Number of leaves	7.49±0.0233	7.46±0.0225	0.03±0.0323	Insignificant.
Area of leaves in sq. cm.	75.37±0.2737	83.32±0.7722	7.95±0.8192	Significant.

TABLE V.—*Showing difference by direction between bearing twigs and twigs of nonbearing robust trees*

Parts	Mean of bearing twigs	Mean of twigs of nonbearing robust trees	Difference	Significance (5×P.E.D.)
East terminal shoots:				
Length of twigs in cm.	14.18±0.0467	20.67±0.2256	6.49±0.2303	Significant.
Diameter of twigs in mm.	6.28±0.0087	7.53±0.0236	1.25±0.0251	Do.
Number of leaves	10.38±0.0250	15.00±0.3479	4.62±0.3488	Do.
Area of leaves in sq. cm.	91.53±0.0892	94.31±0.5364	2.78±0.5437	Do.
East lateral shoots:				
Length of twigs in cm.	14.61±0.0391	23.46±0.2624	8.85±0.2652	Do.
Diameter of twigs in mm.	5.53±0.0061	7.23±0.0529	1.70±0.0532	Do.
Number of leaves	7.22±0.0198	11.28±0.1211	4.06±0.1227	Do.
Area of leaves in sq. cm.	86.08±0.1051	77.27±0.4661	8.81±0.4778	Do.
North terminal shoots:				
Length of twigs in cm.	14.21±0.0402	18.83±0.1637	4.62±0.1685	Do.
Diameter of twigs in mm.	6.28±0.0074	7.38±0.0391	1.10±0.0397	Do.
Number of leaves	10.53±0.0239	13.86±0.1083	3.33±0.1109	Do.
Area of leaves in sq. cm.	90.03±0.0425	94.22±0.5303	4.19±0.5320	Do.
North lateral shoots:				
Length of twigs in cm.	14.73±0.0322	23.48±0.5275	8.75±0.5284	Do.
Diameter of twigs in mm.	5.56±0.0074	7.10±0.4114	1.54±0.4114	Doubtful.
Number of leaves	7.39±0.0228	10.34±0.1056	2.95±0.1080	Significant.
Area of leaves in sq. cm.	88.03±0.0831	77.17±0.5448	10.86±0.5511	Do.
West terminal shoots:				
Length of twigs in cm.	14.25±0.0368	18.72±0.6444	4.47±0.6454	Do.
Diameter of twigs in mm.	6.30±0.0389	7.33±0.0340	1.03±0.0516	Do.
Number of leaves	10.17±0.0243	14.62±0.1062	4.45±0.1085	Do.
Area of leaves in sq. cm.	94.85±0.0883	88.08±0.4152	6.78±0.4244	Do.
West lateral shoots:				
Length of twigs in cm.	15.21±0.0318	22.62±0.1679	7.41±0.1708	Do.
Diameter of twigs in mm.	5.24±0.0090	6.74±0.0503	1.50±0.0503	Do.
Number of leaves	7.27±0.0191	10.32±0.0980	3.05±0.0998	Do.
Area of leaves in sq. cm.	86.40±0.0403	60.99±0.3014	25.41±0.3040	Do.
South lateral shoots:				
Length of twigs in cm.	14.29±0.0344	18.04±0.1872	3.75±0.1903	Do.
Diameter of twigs in mm.	6.38±0.0097	6.98±0.0385	0.60±0.0397	Do.
Number of leaves	10.68±0.0243	12.31±0.1224	1.63±0.1247	Do.
Area of leaves in sq. cm.	100.45±0.1077	82.92±0.4434	17.53±0.4562	Do.
South lateral shoots:				
Length of twigs in cm.	14.75±0.0333	23.84±0.5672	9.09±0.5681	Do.
Diameter of twigs in mm.	5.47±0.0066	6.82±0.0492	1.35±0.0496	Do.
Number of leaves	7.49±0.0233	10.31±0.0998	2.82±0.1024	Do.
Area of leaves in sq. cm.	75.37±0.2737	86.44±0.7601	11.07±0.8078	Do.

TABLE VI.—*Showing difference by direction between bearing twigs and twigs of nonbearing unthrifty trees*

Parts	Mean of bearing twigs	Mean of twigs of nonbearing unthrifty trees	Difference	Significance (5×P.E.D.)
East terminal shoots:				
Length of twigs in cm.	14.18±0.0467	7.08±0.0865	7.10±0.0983	Significant.
Diameter of twigs in mm.	6.28±0.0087	6.38±0.0312	0.10±0.0323	Doubtful.
Number of leaves	10.38±0.0250	9.33±0.1096	1.05±0.1124	Significant.
Area of leaves in sq. cm.	91.53±0.0892	49.62±0.4616	41.91±0.4701	Do.
East lateral shoots:				
Length of twigs in cm.	14.61±0.0391	8.71±0.1401	5.90±0.1454	Do.
Diameter of twigs in mm.	5.53±0.0061	5.68±0.0183	0.15±0.0174	Do.
Number of leaves	7.22±0.0198	7.18±0.0761	0.04±0.0786	Insignifidant.
Area of leaves in sq. cm.	86.08±0.1051	57.60±0.4782	29.02±0.4896	Significant.
North terminal shoots:				
Length of twigs in cm.	14.21±0.0402	6.36±0.1219	7.85±0.1283	Do.
Diameter of twigs in mm.	6.28±0.0074	5.84±0.0172	0.44±0.0187	Do.
Number of leaves	10.53±0.0239	8.40±0.0722	2.13±0.0760	Do.
Area of leaves in sq. cm.	90.03±0.0425	47.10±0.6058	42.93±0.6072	Do.
North lateralshoots:				
Length of twigs in cm.	14.73±0.0322	8.17±0.1034	6.56±0.1082	Do.
Diameter of twigs in mm.	5.56±0.0074	5.24±0.0281	0.32±0.0290	Do.
Number of leaves	7.39±0.0228	6.52±0.0969	0.87±0.0995	Do.
Area of leaves in sq. cm.	88.03±0.0831	40.45±0.2699	47.58±0.2884	Do.
West terminal shoots:				
Length of twigs in cm.	14.25±0.0368	7.92±0.1159	6.33±0.1216	Significant.
Diameter of twigs in mm.	6.30±0.0389	6.24±0.0306	0.06±0.0494	Insignificant.
Number of leaves	10.17±0.0243	11.36±0.0983	1.19±0.1012	Significant.
Area of leaves in sq. cm.	94.85±0.0883	41.01±0.3437	53.84±0.3548	Do.
West lateral shoots:				
Length of twigs in cm.	15.21±0.0318	9.17±0.1160	6.04±0.1202	Do.
Diameter of twigs in mm.	5.24±0.0090	5.27±0.0192	0.03±0.0212	Insignificant.
Number of leaves	7.27±0.0191	6.89±0.0740	0.38±0.0764	Significant.
Area of leaves in sq. cm.	86.40±0.0403	40.57±0.3413	45.83±0.3436	Do.
South terminal shoots:				
Length of twigs in cm.	14.29±0.0344	6.70±0.1265	7.59±0.1310	Do.
Diameter of twigs in mm.	6.38±0.0097	5.97±0.0091	0.41±0.0133	Doubtful.
Number of leaves	10.68±0.0243	10.34±0.1043	0.34±0.1070	Do.
Area of leaves in sq. cm.	100.45±0.1077	50.92±0.4539	49.53±0.4665	Significant.
South lateral shoots:				
Length of twigs in cm.	14.75±0.0333	8.51±0.1352	6.24±0.1392	Do.
Diameter of twigs in mm.	5.47±0.0066	5.34±0.0186	0.13±0.0197	Do.
Number of leaves	7.49±0.0233	7.37±0.0083	0.12±0.0247	Do.
Area of leaves in sq. cm.	75.37±0.2737	41.56±0.4266	33.81±0.5068	Do.

REFERENCES

1. COLLINS, G. N. Correlated characters in maize breeding. Journal of Agricultural Research, Vol. 6, No. 12, (June 19, 1916), 435.
2. ROBERTS, R. H. Off-year apple bearing and apple spur growth. University of Wisconsin Agr. Expt. Sta. Bull. No. 317, (July, 1920).
3. KRAUS, E. J., and H. R. KRAYBILL. Vegetation and reproduction with special reference to the tomato. Oregon Agr. Expt. Sta. Bull. No. 149, (1918).
4. CROW, J. W., and C. C. EIDT. The relation of certain orchard practices to fruit bud formation. Proc. Am. Soc. Hort. Sci., Vol. 18 (1921), 104–108.
5. GARDNER, A. W. The early summer pruning of young apple trees. Oregon Agr. Expt. Sta. Bull. No. 139, (1916).
6. GOURLEY, J. H. Studies in fruit bud formation. New Hampshire College of Agr. Expt. Sta. Bull. No. 8, (Jan., 1915).
7. MAGNESS, J. R. Studies in fruit bud formation. Oregon Agr. Expt. Sta. Bull. No. 146, (1917).
8. KRAYBIL, H. R., G. F. POTTER, S. W. WENTWORTH, P. T. BLOOD, and J. T. SULLIVAN. Some chemical constituents of fruit spurs associated with blossom bud formation in the Baldwin apple. New Hampshire Agr. Expt. Sta. Tech. Bull. No. 29, (Dec., 1925).
9. GOFF, E. S. Principles of plant culture.
10. MAGNESS, J. R., F. L. OVERLEY, and W. A. LACE. Relation of foliage to fruit size and quality in apples and pears. Washington Agr. Expt. Sta. Bull. No. 249, (Feb. 1931).
11. Hayes, H. K., and R. J. GARBER. Breeding crop plants, first edition. McGraw Hill Book Co., Inc., New York, (1921), 125–127.

QUARTERLY NOTES

THE THIRD PHILIPPINE SCIENCE CONVENTION

Under the auspices of the National Research Council of the Philippine Islands and the Philippine Scientific Society, about 200 scientists of the Government, local institutions of learning and private laboratories met in convention from February 26 to March 2, 1935.

The Convention was opened by Dr. Manuel L. Roxas, formerly Under Secretary of Agriculture and Commerce and Commissioner of Research, Chairman of the Natural Research Council. In his opening address, Doctor Roxas made a brilliant defense of the scientific research work in the Philippines, emphasizing the need for "a better understanding of the nature and purposes of research by our lay officials." He urged more support for scientific research, saying: "However viewed in any angle, I can say without fear of successful contradiction that the means which have been placed in the hands of our scientists have been woefully inadequate. Unless this sad state of affairs is remedied progress will remain slow."

Acting Governor-General J. R. Hayden who addressed the Convention expressed that scientific achievement is a good way for a small nation to win the respect and protection of stronger nations. He gave Belgium as an example of a small nation respected for the work of her scientists.

Dr. Jorge Bocobo, President of the University of the Philippines, lauded the progress attained by local scientists in the different branches of science in recent years. He said: "Glancing over the great and wide range of scientific topics discussed by the many papers to be read, one can not but observe the great strides made in recent years in the Philippines in regard to scientific research in all branches of science. Such a convention as this, with such evidence of the scientific spirit in many lines, could not have been possible twenty years ago."

Other notables who addressed the Convention were the Hon. Eulogio Rodriguez, Secretary of Agriculture and Commerce, Mr. Joaquin M. Elizalde, President of the Philippine National Development Company, and Professor H. H. Bartlett, Head of the Department of Botany, University of Michigan and Exchange Professor of Botany, University of the Philippines.

Secretary Rodriguez advised greater emphasis on applied science and quoting Emerson, he said that something is lacking in science until it has been humanized.

"Scientific treatises couched in scientific language are useful and understandable among yourselves who are scientists and who speak the same language," he stated, "but are of no practical benefit to the farmers. It is only when they are shorn of the veil of technicality, it is only when they are brought and simplified to within the understanding of the men in

the fields that they are of real usefulness." He said that scientists can be the instrument of redemption of the Philippines at this time when its salvation lies in economics. "You can perform this rôle," he added, "by transforming scientific abstractions to practical realities."

In its business meetings the following resolutions were approved: (1) Resolution on library facilities for research; (2) resolution requesting the Third Science Convention to coöperate in promoting, coördinating and enlarging the present activities of the National Committee on mental hygiene; (3) resolution recommending resumption of the policy of sending advanced students for specialized training; (4) resolution petitioning the President and the Board of Regents of the University of the Philippines for the continuance and increase of its support to research in the University; (5) resolution placing on record the need of setting aside funds for investigations on water power development; and (6) resolution adhering to the policy of maintaining one central scientific library.

On February 28, the National Research Council held its annual election of officers, the result of which was as follows:

EXECUTIVE BOARD

Dr. Manuel L. Roxas, Member-at-Large and Chairman.
Dr. Angel S. Arguelles, Member-at-Large and Vice-Chairman.
Dr. Bienvenido M. Gonzales, Member-at-Large.
Dr. Patrocinio Valenzuela, Executive Secretary and Treasurer.

Chairman of Divisions

Dr. Victor Buencamino, Chairman, Division of Government, Foreign and Educational Relations.
Dr. Leopoldo A. Faustino, Chairman, Division of Physical and Mathematical Sciences.
Dr. Antonio G. Sison, Chairman, Division of Medical Sciences.
Dr. Amando Clemente, Chairman, Division of Chemical and Pharmaceutical Sciences.
Dr. Eduardo Quisumbing, Chairman, Division of Biological Sciences.
Dir. Jose S. Camus, Chairman, Division of Agriculture and Forestry.
Prof. Hermenegildo B. Reyes, Chairman, Division of Enginering and Industrial Research.

On March 2, the Philippine Scientific Society also held its election of officers, which resulted as follows:

Dr. Eduardo Quisumbing, President
Dr. Arturo Garcia, Vice-President
Dr. Patrocinio Valenzuela, Secretary-Treasurer
Dr. Manuel L. Rozas, Councilor
Dir. Jose S. Camus, Councilor
Dr. Francisco O. Santos, Councilor

BUREAU OF PLANT INDUSTRY REORGANIZATION

Secretary Eulogio Rodriguez approved the plan of reorganization of the Bureau of Plant Industry proposed by Director Jose S. Camus of the said Bureau.

The salient points of the reorganization effected are as follows:

(1) The varied and extensive activities of the Buerau are carried on along the lines of divisional organization, so that the specialists or scientists in different lines of activities may be better developed and more properly grouped together to serve the best interest of the farmers.

(2) The different scientists or specialists who have been given assignments other than their particular specialization, were reassigned to their respective lines of specialty. Likewise, the different sections that properly belong to definite divisions were also restored whenever practicable and every phase of activity so coördinated and systematized as to bring about immediate and more positive results.

(3) Every agronomical district was assigned under a man who is conversant with the different agricultural problems of the district, possessed of a good knowledge of crops and their requirements, acquainted with pathological and entomological work, and in brief, fully fitted to assume the task of rural leadership. Close contact of the Bureau to farms will always be maintained.

(4) The agricultural engineering activity is revived. Agricultural engineering work covers such problems as proper irrigation and drainage, particularly for small farmers, soil reclamation, the use of agricultural machinery and implements, terracing and the conservation of soil fertility, all of which are very important, especially at this time when we need to improve our farm practices to reduce cost of production and improve the quality of the products. These problems are given much attention in other countries as Java, Sumatra and British Malaya, but receives little attention in this country.

(5) A committee on crop survey composed of some of the best trained men of the Bureau was created for the purpose of studying the proper kinds of temporary and permanent crops recommendable for planting in different sections of the Islands, particularly in the specialized agricultural regions such as the sugar cane, coconut and abaca producing provinces. This is in connection with the crop diversification drive which is presently being conducted to increase the source of farm income and make up for the crops affected by limitation.

(6) Greater emphasis is placed on the industrialization of agricultural products such as the abaca sack weaving and rug manufacture from abaca fibers; coconut by-product manufacture as well as door-mat weaving from coconut coir; cotton cloth and miscellaneous fiber weaving; and cassava flour and starch manufacture. In this industrialization work emphasis is laid on the production of those imported products for which enormous sums

of money are drained from the country but a majority of which if not all could be produced in the Islands. The ultimate aim is to make the country self-sufficient and then to be able to export the surplus.

(7) The various research activities of the Bureau are intensified and so adjusted and coördinated as to center first of all on the fundamental problems of the major agricultural industries with the aim in view of producing results that would be of the greatest practical value to the country within the shortest time possible. Simplification of the experiments on the urgent crop problems conducted with the utmost economy to the administration are always borne in mind.

(8) More effective help will be rendered to the farmers through a systematic prgram of demonstraion and publicity on improved farm practices in general.

The reorganization involved a shuffling or realignment of personnel to conform to the objective or rendering a more systematic, efficient and effective service to the public.

ILLUSTRATION

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ORGANIZATION OF THE BUREAU OF PLANT INDUSTRY
AS OF JANUARY 1,1935

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PLATE 1.

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A PRELIMINARY STUDY OF THE INSECT PESTS OF COTTON IN THE PHILIPPINES WITH SUGGESTIONS FOR THEIR CONTROL

By FAUSTINO Q. OTANES
Assistant Chief, Plant Pest and Disease Control
and
FILOMENO L. BUTAC
Junior Plant Inspector

TEN PLATES

INTRODUCTION

Twelve years ago, Mr. H. E. Woodworth (1922), then professor of entomology in the College of Agriculture, University of the Philippines, Los Baños, in an article on the local cotton boll weevil (*Amorphoidea lata*), stated that the subject of cotton pests had apparently received little attention in the Philippines. It was late in 1933 when the subject was taken up for more comprehensive study in view of the widespread interest in the raising of cotton for the purpose of supplying local demand. Accordingly, it has been deemed necessary and timely to put together available information and such local data gathered so far on the various insect enemies of the plant. The cotton planter should at least get acquainted with them, for insects, here in the Philippines as in other countries, constitute a most important factor to contend with. The growing of cotton, a dry-season crop, coincides with the abundance of some of the species of insects affecting the plant—aphids and mealy bugs,

for instance. Even suggestions as to control may be of value to all concerned in minimizing the ravages of the pests of cotton. After this preliminary paper, it is the plan to present, as our investigations progress, a more detailed account of each of the insects on cotton, beneficial or injurious.

The planter should pay more attention to the proper culture of cotton so as to produce vigorous and hardy plants, in order to minimize the expenses for the control of pests and diseases. Among the factors to be considered are the most suitable variety or strain to plant, right time of planting, proper tillage or such practices that will properly conserve the soil moisture, for lack of water makes the plants stunted. There is probably no other annual crop in which moisture, as a climatic or environmental factor, requires more attention than in the case of cotton. Baltazar (1934), for instance, makes the following statement as to the climatic requirements of cotton in which the question of moisture is stressed:

> When young, the crop flourishes best in warm, moist weather. Occasional showers, or light rainfall during the pre-blooming period is very beneficial for the vegetative development of the plant, but too much rain or too much water in the soil tends to increase weeding expense and may cause the plants to produce too much of the woody parts, possibly at the expense of fiber production. On the other hand, severe drought stunts the plant, matures it too early and consequently gives a low yield as the staple produced is small and light. From the time the plant is about to bloom, warm, dry weather is best for the production of a superior heavy-staple crop and for convenient harvesting.

Espino (1920) and Roxas (1931) in their articles on cotton culture likewise give due emphasis on the moisture requirement of the cotton plant.

Moisture, apparently, has an important bearing on insect infestations, by sucking insects in particular. Certain authors, Mumford and Hey (1930), for instance, in an article, entitled "The water balance of plants as a factor in their resistance to insect pests," observed that a disturbed water content, from whatever source, rendered the cotton plant more susceptible to the attack of sap-feeding insects, such as various species of thrips. These authors cited, among those of other workers, their extensive observations in California, where cotton plants receiving an optimum water supply did not have large numbers of thrips, whereas the plants suffering from water shortage seemed definitely more attractive to thrips. While the matter of the water balance of plants as a factor in their resistance

to insect pests and the "water duty practice" as discussed by Wardle (1929), in relation to insect infestations, are subjects that still need to be extensively investigated in connection with individual cases, yet there is certainly no question as to the importance of maintaining a reasonably sufficient moisture in the soil or conserving what is present in the soil, to insure a paying crop of cotton.

In the control of cotton insects—and those of other crops as well—it is hardly possible to depend on any single control method alone. Therefore, in addition to chemical and biological (the employment of parasites and predators) methods of control, the value of hand or mechanical methods should not be underestimated, especially where labor is cheap. The control of leaf eating caterpillars by hand-picking when at first greatly localized, and by simply removing the leaves or parts of the stems affected by initial colonies of mealy bugs may save the planter a great deal of labor and expense. So, also, is the persistent collection and destruction of certain adult insects when they first appear. In the case of the native cotton boll weevil, when the insects begin to appear on the first or early flowers, prompt collection and destruction of the young bolls that have fallen to the ground will materially help to prevent greater infestations later. If the fallen bolls are not picked up promptly and persistently the larvæ or grubs will soon leave them, dig into the soil, and pupate and the resulting beetles will infest all new and succeeding flowers.

BITING OR CHEWING INSECTS AFFECTING COTTON

THE COTTON BOLL WEEVIL (AMORPHOIDAE LATA Motsch). Plate 1, fig. 1.

This is one of the most injurious insect pests of cotton in the Philippines. As the name indicates, the insect is with a snout or beak at the end of which are the teeth and mandibles and other mouth parts. It is a small, dark brown insect, being only from 3 to 4 millimeters long. According to Dammerman (1929), it is also found in India and Java. It seems that it has been known in the Philippines since the early days of scientific agricultural work here under the American régime, as Espino (1920) quotes the following from an early report of the old Bureau of Agriculture:

> . . . during the development of the bolls, they were profuse and very fair crops would have been obtained had it not been for the ravages of weevils and other insect pests. The weevil trouble assumed such a serious stage that a boll rarely reached the picking stage in a perfect condition.

It is apparent that no species other than *Amorphoidea lata* was involved as no other species has been found on cotton, although the identity of the pest, it seems, was not recorded until after several years later. Schultze (1915) noted that *A. lata* was very injurious to cotton.

At Singalong, Manila, the insects have been observed to gather in the newly opened flowers in the morning, usually between 7 and 10 o'clock. The female punctures the young bolls and lays its eggs in the pistil and the resulting larvæ or grubs eat the young seeds and other soft part of the seed capsules. Because of the injury, the young bolls soon fall off.

Life history and habits.—Professor Woodworth (1922) studied to some extent the life history and habits of the insect at the College of Agriculture, Los Baños, but did not suggest any control measure. He found out that under conditions there, the eggs hatched in 1 to 3 days, the average incubation period being 1.5 days. The larval or grub period ranged from 5 to 9 days and the pupal from 3 to 5 days. Its life cycle there, therefore, from the time the eggs are laid to the time the adult beetles emerge, is from 9 to 17 days, the average being 11.8 days.

Professor Woodworth also found that the insect also bred in the flowers of a tree, known in Tagalog as "makarapas" (*Thespesia lampas*) and that the beetles fed on the flowers of other plants related to cotton.

The life history of the insect as observed in the Entomology Laboratory in Manila are as follows:

Incubation period	2 to 3 days
Larval or grub	6 to 11 days
Pupal stage	2 to 5 days
Emergence to first laying of eggs	1 to 4 days

From these data, the life cycle in Manila, therefore, from the time the eggs are laid to that when the adults begin to lay eggs is from 11 to 23 days or an average of 17 days.

Descriptions.—The following descriptions of the different stages of the boll weevil are in the main adapted from Professor Woodworth's article:

Egg.—Smooth, pearly white, elliptical to ovoid; average size 0.64 millimeter long and 0.44 millimeter in diameter. (Plate 3, fig. 1.)

The eggs are laid in the tissue of the opened flower, in the sheath of the ovary or staminal column. The female excavates a small cavity in the tissue of the staminal sheath with her snout, and reversing her posi-

tion, deposits a single egg in this cavity. Several eggs may be deposited in this flower. An average of five eggs per flower has been found.

The larva.—Wrinkled, grayish-white, crescent-shaped, apodous or legless, with a few scattered darker hairs. Head slightly smaller than the body, brown, pale when newly hatched and darker later. About 4 millimeters long and 1.2 millimeters at greatest width when full grown.

Pupa.—Naked and resembles the adults as to form; grayish white with a few scattered darker hairs. Eyes, chocolate brown; mandibles, dark. Elytra or outer wings much darker than the rest of the body.

Adult.—Head, minutely and shallowy pitted, pale to reddish brown and sparsely pubescent; eyes, lateral, convex and nearly circular. Rostrum or beak as long as prothorax; sides, parallel. Antennae, light brown arising from the middle of the rostrum, elbowed, or geniculate; the first segment or scope almost as long as all the succeeding, resting in a groove on the basal half of the rostrum and reaching to the eye; the club conspicuously broader than funicles. Prothorax $1\frac{1}{2}$ times as broad as long; sides, rounded, broadest in middle, narrowed slightly behind and strongly constricted anteriorly, minutely pitted, and pale, with fine sparse pubescense below. Scutellum present. Elytra, ovate, chocolate in color, with golden brown scales, striate and finely pitted. Abdomen below, and legs concolorous with thorax, length 3.5 millimeters, breadth 1.7 to 2 millimeters.

At Singalong, Manila, as many as five larvæ or grubs have been found in a fallen boll. When full grown the larvæ leave the bolls and dig into the soil where they pupate.

Control.—It is thus advisable that the young bolls that fall to the ground be collected every day and burned so as to prevent the pest from increasing rapidly.

Since the beetles congregate or gather in the newly opened flowers, as many as over thirty having been found in one flower, they should be collected and killed. If this is done persistently, especially when the early flowers appear, the damage can be greatly minimized.

In the United States, dusting with calcium arsenate alone is generally employed to control the notorious boll weevil (*Anthonomus grandis* Boheman), a native of Mexico and Central America. The weevil, besides feeding on the cotton leaves, drink the dew on the leaves. The application of calcium arsenate dust on the plants thus results in poisoning and killing the insects and the method has become a general practice among American cotton growers, although the method is not without its drawbacks, as indicated by the work of Folsom and Bondy (1930). They found that excessive applications of calcium arsenate were often followed by heavy infestations of the cotton louse (*Aphis gossypii* Glover).

So far, it has not been found whether the local boll weevil (*Amorphoidea lata* Motsch.) has similar habits as the Mexican boll weevil mentioned above. In fact Woodworth (1922) failed to notice any attack on the leaves and stems. Hence, dusting entire fields with calcium arsenate to control this pest cannot as yet be recommended. However, from our field tests, we have found that dusting the beetles congregated in the newly opened flowers in the morning with a 50–50 mixture by volume of calcium arsenate and "gaogao" (this poison has been extensively employed locally for dusting against locust hoppers) killed the beetles in about half an hour. It would seem that if the insects are abundant on the early flowers, calcium arsenate, either alone or mixed with "gaogao" or other suitable carriers, may be employed. Some cotton plants may also be planted ahead of the main crop and the flowers used as trap by killing the bettles that gather in them by dusting or handpicking.

The bug (*Geocoris tricolor*) has been found to prey on the beetles and on mealy bugs. The insect (Plate 10, fig. 5) is shiny black and is about 5 millimeters long and 2.5 millimeters wide. The dorsal surface of the head is brownish yellow and the eyes are brownish red. The lower surface of the head is pale yellow and the proboscis is of the same color as the dorsal surface of the head. The first and second segments of the antennæ and the distal half of the fourth segment of the antennæ are also pale yellow, the remaining portions (the third and fifth or last segment and the proximal half of the fourth) being black. The legs and the tips of the wings are likewise pale yellow. The notal or dorsal portion of the thorax and the proximal portions of the outer wings are distinctly pitted or punctate.

THE COTTON SEMI-LOOPER OR "ABUTILON MOTH" (COSMOPHILA EROSA Hubn.). (Plate 2, figs. 1 and 3.)

This green semi-looper or measuring caterpillar has been found quite common on cotton as a leaf feeder. Judging from its work, it is capable of great injury when present in abundance. The insect is quite a cosmopolitan species. It is also found in the United States where it is known as "the abutilon moth." There the abutilon plant was found by Chittenden (1913) to be the insect's preferred host. The species is widely distributed in Asia.

Food plants.—Besides on cotton, the caterpillars have been observed to feed locally on the leaves of cowpeas. In Woodworth's host index (1921), okra is included as one of its hosts.

Life history.—The following records of the life history of the insects were obtained in the Entomology Laboratory at Singalong:

Egg stage or incubation period	2 to 3 days
Larval stage	2 to 16 days
Pupal stage	6 to 7 days

The egg (Plate 3, fig. 2).—The egg is somewhat circular in shape, about .6 millimeter in diameter, flattened, with ridges radiating from the center. The eggs are laid singly on the lower surface of the leaves. They vary in color, from light green to bluish green, and can be seen with the naked eye after one has learned to recognize them on the leaves.

The larva or caterpillar.—The caterpillar molts four times, that is, there are five instars.

The first instar caterpillars feed on the lower surface of the leaves, leaving the upper membrane or epidermis. After the first molt, however, the caterpillars consume the whole tissue.

When newly hatched the caterpillars are about a millimeter long and are pale yellow but soon become light green after feeding, and the color becomes more pronounced as they grow older. White parallel lines or markings run practically the whole length of their bodies. The full grown caterpillar is about 4 centimeters long and 3.5 millimeters wide.

The pupa.—Preparatory to pupation, the larva incloses itself by folding a leaf at one side with its silk or thread. It then sheds off its skin, which marks the real beginning of pupation. The pupa is dark brown measuring from 15 to 17 millimeters long and from 4 to 4.5 millimeters in diameter. At the end of the last segment are four spines, two of which are curved downward or ventrad. There are also four bristles which are distinctly longer than the spines and which are curved or rolled at the end (all these are parts of the cremaster).

The adult.—The adult is brownish yellow, about 1.2 centimeters long and has a wing expanse of about 3.8 centimeters. The male is of about the same size. The outer or front wings are with transverse, dark brown wavy lines and the apical or posterior half being darker, being more so in the case of the male. There is a small faint white spot or mark near the front margin of each outer wing about one-third the distance from the base.

Control.—The cotton field should be gone over often and the caterpillars which are usually localized at first should be con-

trolled promptly by dusting or spraying with either lead or calcium arsenate, preferably the latter, as it is cheaper.

For dusting, calcium arsenate may be used alone or diluted with "gaogao" or ordinary inert lime in the proportion of 1 part of calcium arsenate to 5 to 10 parts by volume of the filler or carrier. The dusting can best be done early in the morning when there is dew or when there is no strong breeze.

For spraying, use from 1.5 to 4 grams of calcium arsenate per liter of water or 7 to 14 spoonfuls (levelful) for every petroleum canful (about 5 gallons) of water. Stir vigorously before, and occasionally while spraying to keep the calcium arsenate particles in uniform suspension. A bucket pump, provided with several meters of rubber hose and with a good nozzle that will deliver the spray in a fine mist, may be employed.

Spraying with soap solution at the rate of 10 to 20 grams per liter of water ($\frac{1}{5}$ to $\frac{2}{5}$ kilo per 5 gallons or one petroleum canful of water) has also been found effective, especially on the young caterpillars.

Natural enemies.—A hymenopterous parasite (*Euplectrus* sp.) has been found to attack the caterpillars. This tiny insect (see Plate 2, fig. 1; also Plate 10, figs. 1 to 4, inclusive), which is about a millimeter long, with the head and thorax black and the abdomen and legs and antennae pale yellow, lays its eggs on the back or sides of the caterpillars and the larvae feed on the hosts by consuming their juices. When full grown, they move to the underside of the dead hosts, which are almost all skin, and fasten them to the leaves with silken threads and then pupate. This is certainly of help in keeping the pest in check. It closely resembles another parasite of the same genus previously observed to attack the larvae of the grass armyworm, *Spodoptera mauritia* (Otanes, 1925), and likewise valuable in the control of this pest.

The egg parasite, *Trichogramma minutum* Riley (Plate 9, fig. 6) introduced by Doctor Merino from the United States in March, 1934, has been found to attack the eggs of *Cosmophila erosa* in the laboratory and liberations have been made in the field.

THE COTTON PYRALID LEAF ROLLER (SYLEPTA DEROGATA Fabr.) Plate 2, fig. 2.

Another caterpillar which has been found rather common on cotton is that of a pyralid moth, *Sylepta derogata.* This is known to be an important pest in India. The insect lays its eggs singly on the underside of the leaves like *Cosmophila erosa.*

The caterpillar rolls the leaves wherein it feeds and pupates, a habit which makes the pest more difficult to control than *Cosmophila*.

The life history of the pest as worked out in the Entomology Laboratory at Singalong are as follows:

Egg stage	2 to 3 days
Larval stage	14 to 16 days
Pupal stage	6 to 7 days

The eggs (Plate 3, fig. 3).—The eggs are elliptical, about 0.6 millimeter in diameter and are laid singly, as stated previously, on the lower surface of the leaves. They are pale yellow in color and are difficult to detect on the leaves without the aid of a lens.

The larva or caterpilar.—The caterpilar molts five times, that is, there are six instars.

As in the case of *Cosmophila erosa* the first instar caterpillar feeds on the lower surface of the leaves, leaving the upper membrane. After the first molt the caterpillar begins to consume the whole tissue and to roll the leaves by means of its silky thread-like secretion.

The newly hatched larva is transparent and pale green with pale brown head. In the subsequent instars, the larva's head is brown. The dorsal portion of the prothorax is heavily chitinized and this chitinized area is brown like the head.

The pupa.—The pupa is rolled in usually at one side on the upper surface of a leaf. It is brown, turning darker when the adult is about to emerge. It is from 1 to 1.3 centimeters long and from 2.5 to 3.0 millimeters wide. At the posterior or anal end are eight stout bristles, like those of *Cosmophila,* and are also rolled or curved at the end.

The adult.—The adults are yellowish white measuring from 2 to 2.3 centimeters across the wings. On both fore and hind wings are numerous brown transverse wavy lines. The male is slightly smaller than the female and has its posterior abdomen more pointed and somewhat longer than that of the female.

Control.—1. Spraying with calcium arsenate as suggested for *Cosmophila erosa.*

2. Collecting the caterpillars.

3. Spraying with soap solution with the same strength as given for *Cosmophila* may also be practiced.

A TORTRICID LEAF ROLLER (HOMONA sp.). Plate 2, fig. 4.

Another common caterpillar which has been found on cotton is the larva of a Tortricid moth, *Homona* sp. The insect lays its eggs in masses, the eggs being arranged like scales.

Aside from cotton, caterpillars of the moth have been observed to feed on the leaves of peanut, apple, avocado and citrus.

Life history.—The following are records of the life history of the insect in the Entomology Laboratory at Singalong:

Egg stage or incubation period	5 days
Larval stage	17–18 days
Pupal stage	5–7 days

The eggs (Plate 3, fig. 4).—The eggs are small, flat, elliptical objects laid one overlapping the other. The entire egg-mass, which may contain from 99 to 250 eggs, is flat, elongated and is very smooth and glossy. The eggs are yellowish in color along the periphery, while toward the center, they are translucent.

The larva or caterpillar.—The larva molts five times before attaining full size. Like the larva of *Cosmophila* and *Sylepta,* the newly hatched caterpillar feeds on the under surface of the leaf, leaving the upper membrane. In the succeeding instars, however, the larvae begin to roll the leaf and consume the whole tissue.

The newly hatched larva is pale yellow with the head and thorax dark in color. As the larva grows the dark color of the head and of the dorsal portion of the prothorax is shiny black. A full grown larva measures 2.5 centimeters long and .3 centimeter wide.

The pupa.—The pupa is 7 to 10 millimeters long and from 2 to 3.5 millimeters wide and reddish brown. The dorsal surface of the abdominal segments, are furnished with minute spines arranged across the segments in two rows, the anterior rows being more developed than the posterior ones. The cremaster is also provided with bristles but are distinctly shorter than those of the pupae of *Cosmophila* and *Sylepta*. The bristles are likewise curved or rolled at the end.

The adult.—The adults are brownish-yellow. The male is much smaller than the female being only about 8 millimeters long while the female is 12 millimeters. The male has a prominent "costal fold" of scales at the base of the front or costal margin of the forewing. The wing patterns in both sexes are similar.

Control.—Essentially the same control measures given for *Sylepta* are suggested. Collecting the eggs clusters is also practical.

Hymenopterous parasites have also been reared from the larvæ of *Sylepta* and *Homona* treated in this paper. These are of help in the control of the pest.

Liberations of *Trichogramma minutum* have been made in the field and the parasites have been reared from egg clusters of *Homona* sp., showing that this introduced parasite shows promise of getting established here.

THE PINK BOLLWORM (PECTINOPHORA GOSSYPIELLA Saund.) Plate 3, figs. 5 to 7.

This caterpillar, which is pink in color, (hence, the name) is undoubtedly one of the pests which is capable of serious damage when cotton is grown extensively and should be looked out for closely. It has been reported quite destructive in La Union.

In other countries, as in Brazil, Egypt and Mexico it is known to be the worst pest of cotton, the losses in yield of both lint and seeds being unusually heavy, running to millions of dollars. In the United States, the insect threatens to get established in the cotton belt and the United States spends hundreds of thousands of dollars every year for quarantine and eradication work. Wardle (1929) states that it disputes with the boll weevil (*Anthonomus grandis*) in America, the distinction of being the most important cotton pest in the world.

The adult moth is about 7 millimeters long from the tip of the head to that of the abdomen and 9 millimeters long from the tip of the head to that of either wing when the insect is at rest. The color is somewhat dark brown, with the patches on the forewings, being dusky dark. The forewings are fringed with hairs along the apical margin while the hind wings are fringed both along the apical and anal margins.

The caterpillar is about 1.2 centimeters long and 2.5 millimeter wide when full grown. It is conspicuously pink and the segments are all provided with weak pale yellow hairs or setae. The pupa is reddish brown, about 9 millimeters long and 3.8 millimeters in diameter. It is somewhat densely covered with setae, those at the anal end being distinctly larger and are hooked at the end.

The eggs have not been encountered in this work but according to Hunter (1918) they are laid singly or in small groups on the green bolls or in the flowers. Generally, according to the same authority, the eggs are to be found near the points of the green bolls in the sutures making the locks and as many as 20 eggs have been found on a single boll. The total number of eggs laid by a female was estimated to be about a hundred, the eggs, hatching in from 4 to 12 days. The larval stage during the summer in the United States, according to Hunter, occupies from 20 to 30 days. He cites Gough, in Egypt, as having found that the larvae would remain in a quiescent condition for over two years. He also mentions Busck, who found out that bales of cotton in which were placed infested seeds continued to reveal the presence of live larvae up to 18 months after baling. This ability of the larva to prolong its life as such has made possible the spread of the insect to many countries. The pupal stage, according to Hunter lasts from 10 to 20 days. In the Entomology Laboratory at Singalong, Manila, our record of the pupal period of the insect in November, 1934, is 11 days.

The moths do not live live long, the great majority of them according to Busck's records, dying in confinement in from 14 to 20 days.

Control.—The early matured bolls should be carefully examined for the presence of the caterpillars and all the infested ones should be gathered and fumigated with either carbon bisuiphide or sterilized with heat.

All the cotton seeds should also be fumigated and stored in tightly closed containers. They should be examined regularly for the presence of the pest.

After the harvest, old plants and fallen bolls should be destroyed. All volunteer and useless plants in which the insects may breed prior to the regular crop, and which thus may be the source of infestations to the latter, should be destroyed.

As to the use of natural enemies, Wardle (1929) says that there is really no effective parasite among the numerous ones which have been recorded, such as *Pimpla roborator* in Egypt or *Mirobracon mellitor* in Hawaii. He also says that there would seem to be possibilities among the parasites of the insect in African localities, or among the parasites of the allied species of *Pectinophora*. He adds that an egg parasite, owing to the exposed situation of the eggs, should offer the greatest possibil-

ity. In view of this suggestion, *Trichogramma minutum* (introduced by Dr. G. Merino) now being reared in our laboratory will be tried.

OTHER CATERPILLARS THAT ATTACK COTTON BOLLS

The corn ear worm, *Chloridea* (*Heliothis*) *obsoleta*, which is cosmopolitan, has also been found to attack cotton bolls, but the infestation at Singalong has been found very negligible. Baltazar (1934) states, however, that the caterpillars are a serious pest in the Ilocos provinces, feeding not only on the bolls but also on the flowers and squares, although it is quite possible that other species are involved.

Another caterpillar which has been observed at Singalong is that of *Earias* sp. (most likely *fabia*). The moth is light pink and has a triangular green area on each forewing. There is also a green patch on the dorsal portion of the thorax. The length is a little over a centimeter from the tip of the head to those of the wings when the moth is at rest. The larvae of the species of this genus attacking cotton are known to bore through the stems of the plants.

Handipicking of infested bolls, dusting with poisons and the employment of egg parasites in particular are suggested as control measures.

COTTON LEAF MINER (LITHOCOLLETIS TRIARCHA (Meyrick).[1] Plate 3, fig. 8 and Plate 4 fig. 1.

This has been found rather abundant in Singalong. As the name suggests, the flattened larvae feeds inside the leaves causing blotches or mines which later dry up. Two parasites of this leaf miner have been identified as *Elasmus* sp., near *homonae* Ferr., and *Sympiesis* sp. by Mr. Gahan of the U. S. Bureau of Entomology, which identifications were sent to us by Mr. Cushman of the same institution.

The collection of infested leaves and placing these in wire cages which will allow the parasites to escape and continue their beneficial work but will prevent the escape of the moths is suggested to minimize the attack.

COTTON STEM WEEVIL. Plate 1, figs. 2 and 3.

The larva of a weevil has also been observed to mine within the stems of cotton, causing them to produce swellings or gall-like formations. The plants are stunted and may succumb if

[1] Identified by Mr. Busck, of the U. S. Bureau of Entomology, from specimens taken to the United States by Dr. Merino in 1931, together with specimens of its parasites.

the injury be severe. The adult insect is about 3 millimeters, long, dark gray, and is apparently similar (if not identical) to another (*Phylaitis* sp.) found in India, which is figured in Indian Insect Life (1909) by Lefroy, to which reference Mr. G. C. Bellosillo, of the Bureau of Science, called the senior author's attention.

SUCKING INSECTS AFFECTING COTTON

A number of sucking insects attack cotton, the most important being the common mealy bug (*Ferrisia virgata* Ckll.), the melon aphis (*Aphis gossypii*) and the leaf hopper (*Empoasca flavescens* Fabr.) Besides the mechanical injury done by these insects, and the loss of sap from the host plants, they also exude honeydew, which serves as a medium for the growth of sooty mold, and this interferes with the food-making function (photosynthesis) of the chlorophyll. Then there is the possibility that at least some of these sucking insects may serve as carriers or vectors for the causal organisms or pathogenes of such local diseases affecting cotton or that the punctures caused may facilitate the entrance of such pathogenes. The general effect of all these injuries, together with that of certain other associated causes, is the stunting of the plants. These plants then produce very few or no boll and thus become virtually useless, even if they do not die immediately.

The combined mechanical injury alone by these sucking insects when abundant, to say nothing of the loss of substance on the part of the hosts, must be considerable, to say the least. In this connection published studies in the United States, such as those of King and Cook (1932) on the nature of the injury done to cotton by certain sucking insects are illuminating and may help all concerned in understanding similar injury caused by the local species of sucking insects. The summary of the work of these authors, is worth quoting:

Experiments were begun in 1927 and carried through three years, at Tallulah, La., for the purpose of studying the lesions produced in stems and petioles by the cotton flea hopper and other plant-sucking insects. The object was to determine, if possible, whether the injury to cotton following the feeding of these insects was the result of a transmissible virus or due to mechanical or chemical injury.

External indications of injury seemed to prove that only a part of the many insects tested had affected the plants in the way considered charac-

teristic of hopper injury, but later examination by microtome sections through the feeding points showed that practically all punctures resulted in the same type of internal injury. The swelling and breaking open of the lesions in some cases seemed to be the result of more extensive injury rather than injury of another kind.

The size of the lesions produced by one individual in consecutive feedings was often fairly uniform, but the toxicity of different individuals was decidedly variable.

The early reaction of the internal tissues of the plant is recognizable as an enlargement of nuclei and cells at some point along the feedings puncture. This has been observed in material preserved for sectioning 24 hours after the feeding. Dividing nuclei occasionally found in the preparations show that cell division is stimulated, and in this respect the lesions are comparable to the reaction of the plant to wound stimuli. The milder lesions may show only evidence of cell activity and more or less cell distortion, whereas in more severe forms areas of broken-down tissue develop. The full development of the lesion is rapid; and the external swellings, when produced at all, are usually visible by the second or third day.

Individuals of 10 species (7 Hemiptera and 3 Homoptera) were included in the tests. The average severity of the damage by different species was variable. Of the two more important field pests, the percentage of split lesions was 32.6 for *Lygus pratensis* and 9.5 for *Psallus seriatus*. About 7 per cent of the lesions caused by *P. seriatus* and 10 per cent of those caused by *L. pratensis* did not show externally. *Poeciloscytus basalis*, a species which is seldom taken on cotton, caused external swellings at every feeding point and produced the highest percentage of split lesions (58.2) of any of the species tested. Of all the individuals that fed more than once only two failed to produce the injury at some feeding point.

The feeding punctures of the three species of Homoptera used in the tests can be traced through the tissues by a well-defined "sheath" which stains a bright red with safranin. This may be found in sections made immediately after the feeding of the insects and is similar in appearance to the sheaths which have been described in aphid punctures. As in the case of the aphids, the paths usually end in the vascular tissue.

No sheath material was found about the punctures made by mirids, and the path taken by the proboscis of the species on which observations were made could not be definitely traced. At the most, in plant material preserved for sectioning soon after the feedings, a few ruptured cells have been found.

The experiments with the 10 species of plant-sucking insects, some of which do not feed naturally on cotton, have shown that nearly all individuals cause a reaction in the tissues of cotton stems and leaf petioles similar to that produced by the cotton flea hopper, *Psallus seriatus*. This is taken to indicate that hopper damage is due to injected substances normally present in the insects and toxic to the plant, rather than to a transmissible disease.

THE COMMON MEALY BUG (FERRISIA VIRGATA Ckll.) Plate 5, figs. 1 and 2; see also Plate 9, fig. 1.

The mealy bug, *Ferrisia* (*Pseudococcus*) *virgata* Ckll., has been observed rather serious to cotton at Singalong, Manila, and in other places, during the dry season. These insects are very prolific and in a relatively short time they practically cover the stems. They also attack the leaves.

This is undoubtedly the most common mealy bug in the Philippines and has a long list of host plants. Among other hosts, besides cotton, are eggplant, tomato, mango (*Mangifera indica*) different kinds of "San Francisco" (*Codiaeum* sp.), anona and guayabano, (*Anona* spp.) casoy (*Anacardium occidentale*) compea (*Vigna* sp.) cabbage, pechay (*Brassica* spp.) upon (*Lagenaria* sp.), patola (*Luffa* sp.), citrus, guava (*Psidium guajaba*) and gumamela (*Hibiscus* sp.). Among its recorded wild or semi-wild host plants are madre de cacao (*Gliricidia sepium*), ipil-ipil (*Leucaena glauca*) and macahia (*Mimosa pudica*). This species also occurs in other countries, such as Hawaii, Jamaica, Java, etc.

Superficially, it can be distinguished from other local mealy bugs by its having two prominent or conspicuous tail-like waxy fringes at the posterior or hind end of its body. Besides the powdery secretion covering especially the upper surface of its body the insect also has numerous glassy threads or filaments with which the newly born young are concealed. The mature female is from 4 to 5.5 millimeters long. Examined under the microscope, the antennae are 8-segmented and the tarsal claws are without teeth or denticles. These and other peculiar characters led Fullaway (1923) to place it under a separate genus, *Ferrisia* in honor of Dr. G. F. Ferris of Standford University, who (1919) made a careful study of its microscopic morphological characters. The new genus apparently has been accepted by other workers, among them being Takahashi (1924) who also records *Ferrisia virgata* in Formosa. For the microscopic characters of the species, one may also refer to Morrison's paper (1920).

Although this mealy bug has many enemies, three kinds of parasites having been reared in the course of this work and that it is also preyed upon by lady beetles (among them being the common lady-bird beetle (*Chilomenes sexmaculata*), and a species of *Scymnus* and aphis lions and the bug, *Geocoris tricolor*, it usually gains the upper hand during the dry season and causes

considerable harm. The insect becomes full grown in about a month and begins to produce many youngs a few days thereafter.

Colonies of this mealy bug are attended by several species of ants, among them being the common red ground ant, *Solenopsis geminata*.

THE MELON APHID (APHIS GOSSYPII). Plate 6, fig. 1; see also Plate 9, fig. 2.

The melon aphid (*Aphis gossypii*) vies with the mealy bug (*Ferrisia virgata*) in destructiveness. It has been observed that they attack cotton very early and retard their growth. At Singalong, Manila, cotton plants two weeks old planted in October, 1934, were found badly infested by this species.

This insect is cosmopolitan and is very variable in color as well as in size. As is true with other plant lice, both winged and wingless mothers are present and both reproduce parthenogenetically, that is without previous fertilization as is apparently true in the case of aphids in tropical and other warm climates, and of greenhouse aphids in temperate climates, as has been previously observed by Uichanco (1921 and 1924). The following partial statement by Patch, given by Wall (1933) on the variability of *Aphis gossypii* is hereby quoted (those in parentheses are ours):

> The colonies of the melon aphid present a motley appearance when these insects are crowded together on the underside of a leaf. Among the wingless viviparous females (the females that bring forth young actively alive) the colors may range from pale green to greenish black, or from nearly white to lemon yellow . . .
>
> In size the species varies as much as it does in color, and there are thus two reasons why the species has been named and renamed. Individuals of different sizes and colors and on different plants would be easily mistaken for different species . . .

On bearing cotton plants that were somewhat heavily infested, at Singalong, Manila, both in the field and in the greenhouse in November, 1934, most of the insects were lemon yellow in color and some were dull yellow with a greenish tinge and the adult insects were about a millimeter long and even somewhat less. In this connection the findings of Wall at St. Paul, Minnesotta are worth quoting (those in parenthesis are ours):

> In the greenhouse as long as the infestations on cucumber vines have remained sparse, the dark and intermediate colors have predominated among the apterae (without wings), the light colored individuals being exceedingly scarce. Repeated fumigation or spray control will hold a population to a very low figure and it is under such circumstances that

the complexion of the colonies will remain generally dark. On the other hand, either in the field or under glass, the light forms become very numerous, as a rule, when a condition of heavy infestation was reached . . .

Wall has also found that the darker forms (dark green, dusky yellowish green, dusky dull green) werein general bigger than the light colored individuals (pale white, lemon yellow and lighter shades of green).

The melon aphid has also been observed locally abundant on eggplants, melons, upo, cucumber and pechay and other cruciferous plants. Lady beetles, particularly *Chilomenes sex-maculata* (Plate 10, fig. 6) syrphid flies, aphis lion and a certain hymenopterous parasite, apparently of the family Aphelinidae, have been found to prey on it. Parasitized aphids are black and thus can be easily distinguished from the live ones, which are mostly yellow in color.

Colonies of this aphid are also attended by the red ant (*Selenopsis geminata*) and other ants. Colonies of the red ant in particular should be destroyed, preferably with the use of poisonous substances such as calcium cyanide and poisoned syrups, as they encourage the multiplication of the aphids.

LEAF HOPPERS (EMPOASCA FLAVESCENS Fabr.)[1]. Plate 7, fig. 1; see also Plate 9, fig. 3.

The most common leaf hopper on cotton is a small green species (*Empoasca flavescens* Fabr.), measuring about 3 millimeters in length. Like the melon aphid and the common mealy bug (*Ferrisia virgata*), they become very numerous towards the end of the rainy season and cause serious harm to the cotton crop. In 1926, the senior author observed that this leaf-hopper and the melon aphid and mites were chiefly responsible for the failure of an extensive cotton planting at Novaliches, Rizal.

The female deposits her eggs in the midribs of the cotton plants causing the injured spots to swell. Both the adults and the young are voracious feeders causing the leaves to wrinkle or curl up. They also attack eggplants and potatoes.

THE COTTON STAINERS (VACAVACAHAN) (DYSDERCUS spp.)

The farmers are very familiar with these insects so that they hardly need any description here. The species most common on cotton is *Dysdercus megalopygus* (Plate 8, fig. 1).

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[1] This identification and that of Machaerota ensifera Burn., were verified by Doctor Merino.

The adults and the young or nymphs attack especially the cotton bolls. The eggs are laid in the soil, hence they are seldom seen.

The insects have many other host plants both wild and cultivated, giving preference to those of the family Malvaceae to which cotton belongs.

THRIPS. Plate 8, fig. 2 and Plate 9, fig. 5.

Two species have been observed on cotton causing the leaves to appear spotted or whitish. One of these—the bigger species—is a black one about a millimeter long and the wings are black and white. The smaller one is pale yellow and is the more common in the field.

The onion thrips (*Thrips tabaci*) is also recorded on cotton but we are not certain as yet as to the identity of this and the pale yellow one just mentioned here.

A black bug about 4 millimeters long and which may be mistaken for an ant has been observed to prey on the thrips.

RED SPIDERS OR MITES.

A red spider (*Tetranychus* sp.) has been observed abundant on cotton especially during the dry season. The nature of their injury resembles that of thrips. This red spider has also been found to attack beans and peas.

WHITE FLY (BEMISIA sp.). Plate 6, fig. 2; also Plate 9, fig. 4.

This white fly, which commonly attacks cabbage, also attacks cotton. Under greenhouse conditions, it has been found very harmful, attacking not only cotton and cabbage, but also cauliflower, tobacco, tomato and pechay. It has also been observed on roses and on certain other ornamental plants.

The adult insect is about a millimeter long and the body is yellow with its wings snow white and opaque. The eggs are laid in groups on the lower surface of the host plants. The characters of the pupal case and the adult conform to those given by Quaintance (1914) for the genus *Bemisia*. The insect closely resembles *Bemisia gossypiperda* M. and L., also a cotton pest in Sudia (Husain and Trehan, 1933). The nymps and pupae are preyed upon by a hymenopterous parasite and a ladybird beetle.

CERCOPID.

A species of Cercopid, *Machaerota ensifera* Burm., has also been observed on cotton. This feeds chiefly on the tender parts

of the stems of cotton. It is not usually abundant, however, and may be considered a minor pest. The insect is about 5 millimeters long, yellowish brown and has its scutellum produced into a spine which is directed backward.

CONTROL MEASURES FOR THE SUCKING INSECTS ON COTTON

The cotton planter should make efforts to control initial infestations. The mealy bugs and the aphids, especially, are at first localized. Soon after germination, the plants are usually attacked by these pests and the planter should go over the field often and examine the plants and initial colonies of these insects should be destroyed. Even crushing them with the fingers will help. They can best be destroyed, however, by spraying. It pays to have a good spraying equipment on hand, if one is to properly protect his crop from insect pests as well as diseases, if these be present. The following formula for destroying aphids as well as certain other sucking insects on cotton, (the thrips, white flies, the leaf hoppers) and the mites, dealt with in this paper, is suggested:

> Soft yellow, laundry soap—5 to 10 grams per liter of water or approximately $1/10$ to $2/10$ of a kilo in one petroleum-canful of water.

For the mealy bugs and the stainers a stronger solution is necessary to insure killing them. The amount of soft, yellow laundry soap should be doubled, that is, 10 to 20 grams per liter of water or approximately $\frac{1}{5}$ to $\frac{2}{5}$ of a kilo for every petroleum canful of water. The amount of soap may be increased.

Powdered soap, which is especially convenient for combating insects, is now in the market. It dissolves easily by vigorous stirring for a few minutes. This costs about ₱2.60 per 5 gallon can or about 12 kilos. Ten to thirty spoonfuls (levelful) for every petroleum canful of water have been found sufficient for killing plant lice, mealy bugs and other insects, like thrips, white flies and their larvae, and the cotton stainer. Mites also are killed by the soap solution.

If desired, tobacco infusion may be employed instead of pure water with the soap. For preparing this, tobacco stems, midribs, and other tobacco refuse may be employed. Enough of these are soaked in water in barrels or petroleum cans overnight. Strain before using to get rid of any tobacco parts which might clog up the nozzles of the spray pump.

In spraying against aphids, mealy bugs, and leaf hoppers, in particular, direct the spray to the under side of the leaves to be sure the insects are thoroughly moistened with the solution.

OTHER INSECTS ON COTTON

The following sucking insects have also been observed in this work on cotton but were very few and may be considered of minor importance:

Sucking insects:
- *Dysdercus poecilus* H. S.
- *Tectocoris lineola*
- *Saissetia hemisphaerica* (Plate 7, fig. 2)
- *Nezara viridula*
- *Drosicha townsendi*
- *Ricania speculum*
- *Dictyoprara* sp.

Biting insects:
- *Phaneroptera furcifera* Stal.
- *Prodenia litura*

The following are mentioned by Baltazar (1934) but have not been personally observed by us:

Sucking insects:
- *Helopeltis* spp., said to be serious at the College of Agriculture, Los Baños.
- *Antilochus nigripes.* (Specimens were collected by Mr. Toquero of our Division from cotton in Ilocos Norte in 1931.)

Biting insects:
- *Euproctis varians*
- *Acontia intersepta*

Dammerman (1929), in his book, "The Agricultural Zoölogy of the Malay Archipelago," gives the following insects as feeding on cotton among other host plants and they are listed here for some of them at least, occur in the Philippines:

Zeuzera coffeae Nieth. The red coffee borer, the adult being a moth.

Earias fabia Stoll and *Earias Insulana* Boisd., both noctuids. The caterpillars are boll feeders. Both are recorded in the Philippines and our specimens of *Earias* are probably of the former species but this has to be verified.

Collyris bonelli—a tiger beetle.

Aelopus (*Epacromia*) *tamulus* F.—a grasshopper. Recorded.

Glyphodes indica Saund—a pyralid moth. The caterpillars attack cucurbitaceous plants in the Philippines.

Euproctes (*Porthesia*) *scintillans* Wlk.—a lymantrid caterpillar said to be a serious pest of castor plant in the Malay Peninsula.

Nisotra gemella Erichs.—A flea beetle 2.5 to 3.5 millimeters long. According to Reveche (1922), this insect feeds on okra, roselle, gumamela, culotculotan, etc., but apparently he had not observed it on cotton.

Hypomeces squamosus F.—a weevil (Curculionidae).

Mylabris postulata Thunb.—a Cantharid (Meloidae). The larvae are well known predators of locust eggs but the adults feed on the pollen of flowers, including those of cotton.

Oxycarenus lugubris Match., of the family Lygaeidae; commonly known as the black cotton bug; 3.5 to 4 millimeters long with the forewings yellowish white, the central part being brown. The insects suck the juices of the seeds. This is listed by Woodworth (1921).

Dacus ferrugineus F. This is the mango fruit fly, the insect having been noticed in cotton bolls.

Lecanium (Saissetia) nigrum Nietn., a scale insect.

Pinnasphis aspidistriae Sign., a scale insect.

Pseudococcus citri Risso—a mealy bug, closely resembling *Pseudococcus lilacinus*, which is quite common in the Philippines.

Tetranychus coffeae Nietn. (*bioculatus* W. M.), the red tea mite.

The following are also listed by Woodworth (1921) as feeding on cotton but have not been observed by us:

Hypolimnas masippus Linn., a nymphalid.
Hippotion celerio Linn., a sphinx moth.
Euxoa segetis Chiff., a noctuid.
Oxycarenus hyalinipennis Costa, a bug (Lygaeidae).
Scale insects:
- *Hemichionaspis townsendi* Ckll.
- *Pseudococcus filamentosus* Ckll.
- *Saissetia nigra* Nietn. (listed by Dammerman as *Lecanium* (*Saissetia*) *nigrum* Nietn.

Woodworth also lists *Homona menciana* Walk. We are not certain as yet whether this is the same as the species we have found on cotton.

In addition to these records, the following item from Espino (1915) about cotton pests reported by a Spanish investigator prior to American Occupation is of interest:

> The insect enemies of cotton reported during the Spanish regime in these Islands are 'grillo de los campos' (cricket), la oruga gris de una mariposa (Noctua subterranea) and "larva del Melolontha vulgaris."

The *Noctua subterranea*, as quoted by Espino, may be either one of the common noctuids, *Prodenia litura* or *Chloridea* (*Heliothis*) *obsoleta*, which attack cotton, and larvae of which pupate in the soli. *Melolontha vulgaris* is a European species and is not recorded in the Philippines. It is most likely that the larva

involved was that of the "toy-beetle," *Leucopholis irrorata* Chevr., the most destructive grubs here and attacks the roots of many crops (Otanes, 1931) including possibly cotton. Should these and other grubs be found abundant on lands that are being prepared for cotton, they should be collected and killed. Certain other control measures, such as collecting the beetles and spraying their favorite food plants may be employed.

SUMMARY

In this survey an attempt has been made to bring together all the insects and other allied organisms that are known so far to feed on cotton in the Philippines. The species given by Dammerman in his book "The Agricultural Zoölogy of the Malay Archipelago" as feeding on cotton are included, for they are found in the Philippines although some of them have not been locally observed or recorded as yet to feed on cotton, so far as we have ascertained. Two of these are the red coffee borer, *Zeuzera coffeae* and the mango fruit fly, *Dacus ferrugineus.*

Additional life history data and other observations given for the cotton boll weevil, *Amorphoidea lata* Motsch. are given. Similar local observations on other important cotton pests, namely, on three leaf-feeding caterpillars, *Cosmophila erosa* Hubn., *Sylepta derogata* Hubn., *Homona* sp., and on the pink bollworm, *Pectinophora gossypiella* Saund. and the common mealy bug *Ferrisia virgata* Ckll., are also being presented for the first time.

The following are apparently new local records of insects attacking cotton:

1. A weevil, the larvae of which mine or bore within the cotton stems. It is apparently closely related to a cotton pest in India, figured by Maxwell-Lefroy and Howlett, as *Phylaitis* sp.[1]
2. An aleyrodid, *Bemisia* sp.
3. At least two kinds of thrips.
4. *Machaerota ensifera,* a cercopid.
5. A bollworm *Earias* sp.—most likely *fabia.* Caterpillars of the genus *Earias* are serious pests of cotton in other countries.
6. A cotton leaf miner, *Lithocolletis triarcha.*

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[1] A lepidopterous stem borer has also been reported from Hacienda Luisita, Tarlac (see plate 4, fig. 2). The insect proved to be the same as the one reared at Singalong and dealt with in this paper as *Earias* sp. (F.Q.O.)

Based on this preliminary survey, the cotton boll weevil (*Amorphoidea lata*), the pink bollworm (*Pectinophora gossypiella*) and the other caterpillars attacking the bolls, *Chloridea obsoleta* and *Earias* sp. are among the most important biting insect pests of cotton here. The most serious sucking insects are the common mealy bug, *Ferrisia virgata*, the melon aphid, *Aphis gossypii*, and the jassid, *Empoasca flavescens*. The last two, together with red spiders, were chiefly responsible for the failure of an extensive cotton planting in Novaliches, Rizal, in 1926.

The leaf eating caterpillars, *Cosmophila erosa, Sylepta derogata, Homona* sp. and the leaf miner, *Lithocolletis triarcha* are also capable of serious damage when abundant. Because of its habits, the stem borers should be considered as an important cotton pest—more important even than some of the bollworms.

Certain local natural enemies of the important cotton pests are recorded.

Prompt control of initial infestations of any one of the most important cotton insects is urged, considering the income per hectare of cotton compared with certain other crops, is much less and the small farmer therefore can hardly afford to employ insecticides. The value of vigilance and of mechanical methods of control, such as handpicking for controlling certain pests, at least, such as the adult boll weevils, leaf eating caterpillars, should not be underestimated.

Attention is also called to the proper culture of cotton so as to produce vigorous and hardy plants, and in this way at least minimize expenses for controlling insect pests as well as diseases. In this connection, attention to the water requirement of the cotton plant is stressed. Attention is also called to the so-called "water balance of plants" and "water duty practice" in connection with insect infestations.

Attention is likewise called to the possibilities of employing the newly introduced *Trichogramma minutum*, especially in connection with the control of the lepidopterous pests, the bollworms in particular. This species shows indication of becoming established here, having been already reared from Tortricid eggs where liberations have been made.

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LITERATURE CITED

1. BALTAZAR, E. P. 1934. Cotton culture. The Philippine Agriculturist, Vol. 23, No. 4, pp. 267 to 285.
2. CHITTENDEN, F. H. 1913. The Abutilon moth. Bulletin No. 126, Bureau of Entomology, U. S. Department of Agriculture.
3. DAMMERMAN, K. W. 1929. The agricultural zoölogy of the Malay Archipelago, J. H. de Bussy Ltd., Amsterdam, Holland.
4. ESPINO, R. B. 1920. Cotton. Philippine Agricultural Review, Vol. 13, No. 3, pp. 186 to 210.
5. FERRIS, G. F. 1919. Observations on some mealy bugs, Hemiptera, Coccidae. Journal of Economic Entomology, Vol. 12, No. 4, pp. 292 to 299.
6. FOLSOM, J. W. and Bondy, F. F. 1930. Calcium arsenate dusting as a cause of aphid infestation. Circular No. 116, U. S. Dept. of Agriculture, Washington, D. C.
7. FULLAWAY, D. T. 1923. Notes on the mealy bugs of economic importance. Proceedings Hawaiian Entomological Society, Vol. 5 pp. 305 to 321.
8. HUNTER, W. D. 1918. The pink bollworm with special reference to steps taken by the Department of Agriculture to prevent its establishment in the United States, Bull. No. 723, U. S. Dept. of Agriculture.
9. HUSAIN, A. M. and TREHAN, K. N. 1933. Observations on the life-history, bionomics and control of the white-fly of cotton. The Indian Journal of Agricultural Science, Vol. 3, part 5 (Oct., 1933).
10. KING, W. V. and COOK, W. S. 1932. Feeding punctures of mirids and other plant-sucking insects and their effect on cotton. Technical Bulletin No. 296, U. S. Dept. of Agriculture.
11. MAXWELL-LEFROY and HOWLETT, F. M. 1909. Indian Insect Life; p. 389, plate 27.
12. MORRISON, H. 1920. The Nondiaspine coccidae of the Philippine Islands, with descriptions of apparently new species. The Philippine Journal of Science, Vol. 17, No. 2, pp. 147 to 202.
13. MUMFORD, E. P. and HEY, D. H. 1930. The water balance of plants as a factor in their resistance to inscet pests. Agricultural Journal of India, Vol. 25, pp. 330 to 331.
14. OTANES, F. Q. 1925. Insects: Their relation to man and their control. Philippine Agricultural Review, Vol. 8, No. 4, pp. 373 to 410.

15. OTANES, F. Q. 1931. Notes on cane grubs in Batangas and Occidental Negros. Philippine Journal of Agriculture, Vol. 2 No. 2, pages 373 to 410 (see also Sugar News (Manila, P. I), Vol. 13 (1932), No. 1).
16. QUAINTANCE, A. L. and BAKER, A. C. 1914. Classification of the Aleyrodidae. Technical Series, Part II, Bureau of Entomology, U. S. Dept. of Agriculture.
17. REVECHE, F. R. 1922. Life history and habits of some common Philippine flea beetles. The Philippine Agriculturist, Vol. 11, No. 2, pp. 29 to 48.
18. ROXAS, M. L. 1931. Cotton in the Philippines. Crop Diversification Number, Fortnightly News, Bureau of Plant Industry, Manila pages 39 and 40.
19. SCHULTZE, W. 1915. A catalogue of Philippine coleoptera. Bureau of Science, Manila.
20. TAKAHASHI, R. 1929. Observations on the coccidae of Formosa, Part I. Department of Agriculture, Taihoku, Formosa, Japan.
21. UICHANCO, L. B. 1921. Reproduction in the aphididae with a consideration of the modifying influence of environmental factors. Psyche, Vol. 28, No. 4, pp. 96 to 109.
22. UICHANCO, L. B. 1924. Studies on the embryogeny and postnatal development of the aphididae, etc. Phil. Journal of Science, Vol. 24, No. 2, pp. 143 to 247.
23. WALL, R. E. 1933. A study of color and color variation in *Aphis gossypii* Glover. Annals of the Entomological Society of America, Vol. 26, No. 3, pp. 425 to 460.
24. WARDLE, R. A. 1929. The problems of applied entomology, McGraw-Hill Book Co., New York, N. Y.
25. WOODWORTH, H. E. 1921. A host index of insects injurious to Philippine crops. The Philippine Agriculturist, Vol. 10, No. 1, pp. 9 to 35. (See also Vol. 10, No. 7 and Vol. 11, No. 2.)
26. WOODWORTH, H. E. 1922. The Philippine cotton boll weevil. The Philippine Agriculturist, Vol. 10, No. 3, pp. 75 to 81.

ILLUSTRATIONS

PLATE 1

FIG. 1. The cotton boll weevil (*Amorphoidea lata* Motsch.) showing larvæ, pupae and adults.

2. The cotton stem weevil (related to *Phylaitis* sp. in India).
3. Portions of cotton stems showing injury by larvae of the cotton stem weevil.

PLATE 2

FIG. 1. The "Abuliton moth" (*Cosmophila erosa* Hubn.) showing adult moths, larvae and pupae, parasitized caterpillar and parasites (see also Plate 10 for the parasites, enlarged).

2. The pyralid cotton leaf folder (*Sylepta derogata* Fabr.) showing an adult moth, caterpillars and pupae.
3. Caterpillars of (*Cosmophila erosa*) on cotton leaves showing nature of damage.
4. Tortricid leaf roller (*Homona* sp.) showing female and male moths, caterpillars and pupae.

PLATE 3

FIG. 1. Egg of cotton boll weevil (*Amosphoidea lata*). Enlarged, ×20.

2. Egg of *Cosmophila erosa*, ×28.
3. Egg of *Sylepta derogata*, ×19.
4. Egg mass of the Tortricid leaf roller, *Homona* sp., ×1.6.
5. 6 and 7, caterpillar, pupa and adult, respectively, of the pink boll worm (*Pectinophora gossypiella*), ×5, ×5, ×3, respectively.
8. Adult of the cotton leaf miner (*Lithocolletis triarcha*) Meyrick, ×20.

PLATE 4

FIG. 1. Cotton leaves showing injury by the cotton leaf miner, indicated by arrows.

2. Portions of cotton stems showing injury by a lepidopterous insect. A caterpillar is shown by an arrow.

PLATE 5

FIG. 1. A leaf and a portion of the stem of cotton showing mealy bug (*Ferrisia virgata* Ckll.) infestation. See also plate 8, fig. 1.

2. Cotton plants at Singalong, Manila, showing a heavy infestation by mealy bugs (*Ferrisia virgata*).

PLATE 6

FIG. 1. Cotton leaves showing melon aphid (*Aphis gossypii*). See also Plate 9, fig. 2.

2. Cotton leaves showing larvae and pupae of the white fly (*Bemisia* sp.). Adults are also shown. See also Plate 9, fig. 4, which shows how the adult white flies look like.

PLATE 7

FIG. 1. A tree cotton showing nature of injury by the leaf hoppers, *Empoasca flavescens.* Note the curled up leaves. Aphids and mealy bugs were also found on the plant thus contributing to the injury.

2. Scale insects (*Saissetia hemisphaerica*).
3. Cotton leaves at left showing melon aphids, *Aphis gossypii.* Eggs (at A), larva and pupa (at B) and adults of ladybird beetle, *Chilomenes sexmaculata* (at C) which is predatory on the aphids, are shown.

PLATE 8

FIG. 1. The cotton stainer (*Dysdercus megalopygus*) and nymphs. A cotton boll showing effect of the punctures is likewise shown.

2. Normal cotton leaf at left. At right, a cotton leaf showing nature of injury by thrips. (The work of red spiders or mites resembles that of thrips.)

PLATE 9

FIG. 1. A mealy bug (*Ferrisia virgata*), enlarged, ×6.

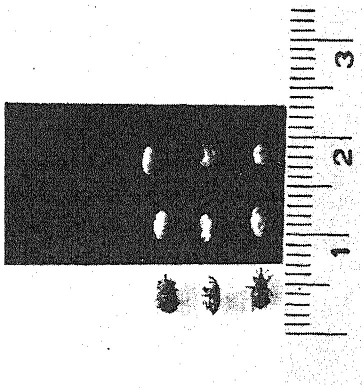
2. A wingless female of melon aphis (*Aphis gossypii*), ×34.
3. A leaf hopper (*Empoasca flavescens*), enlarged, ×10.
4. White flies (*Bemisia* sp.), ×4.
5. One of the thrips on cotton, enlarged about ×40.
6. The egg parasite, *Trichogramma minutum*, introduced by Dr. Merino, ×73. (This introduced parasite has given indication of becoming established, having been reared from the eggs of *Homona* sp., and a nymphalid butterfly.)

PLATE 10

FIG. 1. A parasite (*Euplectrus* sp.) of the caterpillar of the "Abutilon Moth," enlarged, ×21.

2. A caterpillar of same moth showing eggs of the parasite, as indicated by arrows, ×6.
3. A parasitized caterpillar. The larvae of the parasites had moved underneath the caterpillar and had fastened the dead caterpillar to a leaf by means of their silken saliva, ×5.
4. A full grown larva of the parasite, ×13.
5. A bug (*Geocoris tricolor*), a predator of the adult cotton boll weevil (*Amorphoidea lata*) and certain other insects, ×4.
6. Adult ladybird beetle. (*Chilomenes sexmaculata*), a plant lice predator, ×4.
7. Another ladybird beetle, ×4.

(All photographs were taken by the Division of Publications, Department of Agriculture and Commerce and the drawings by the authors.)



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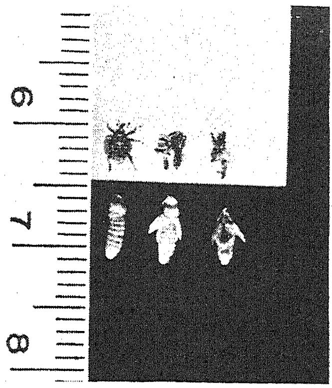

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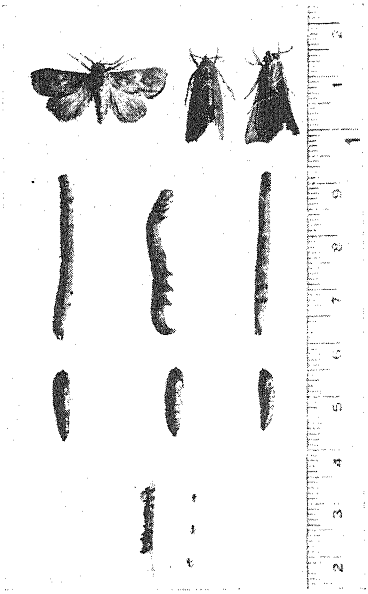

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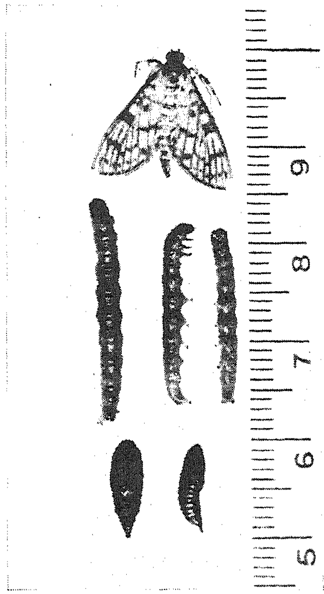

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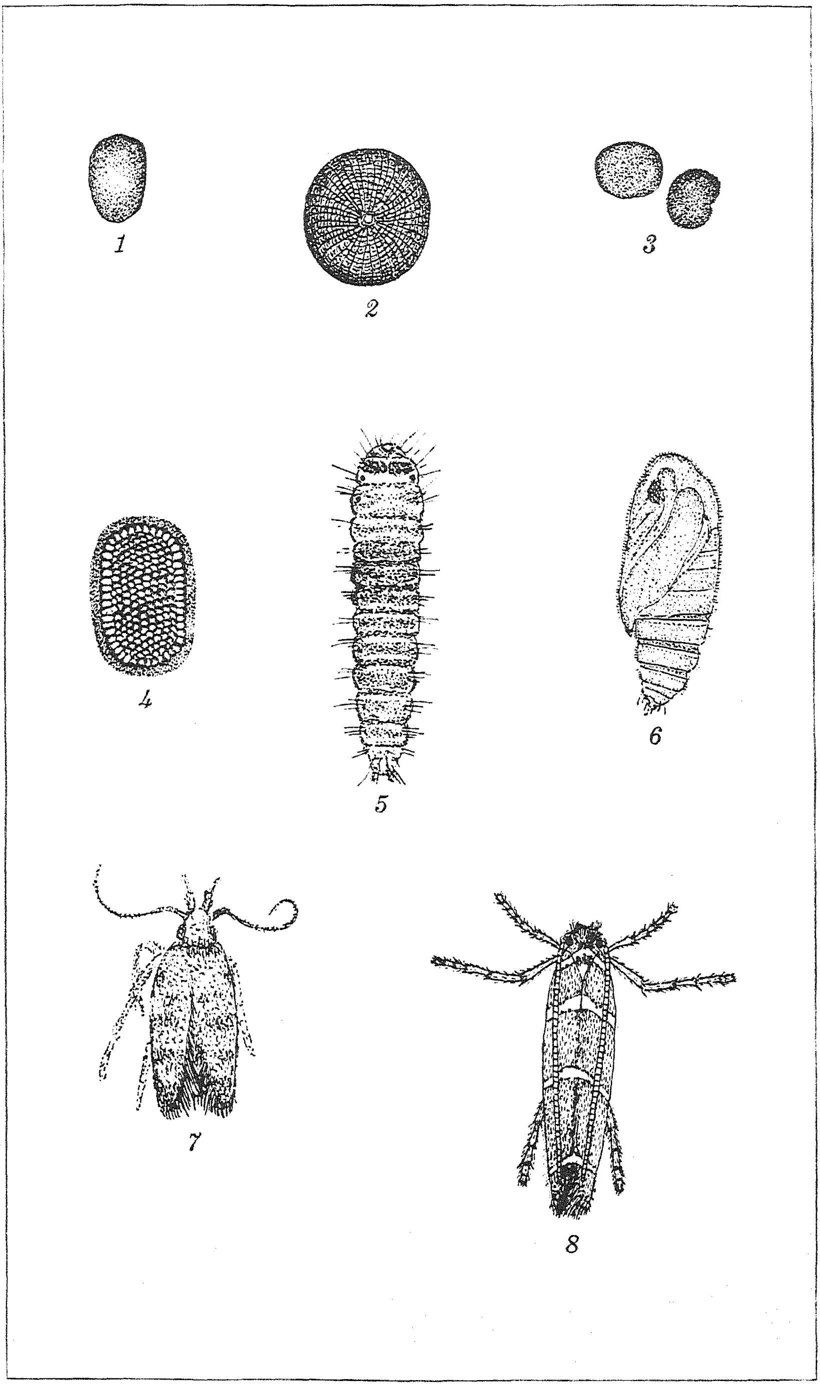
PLATE 2.



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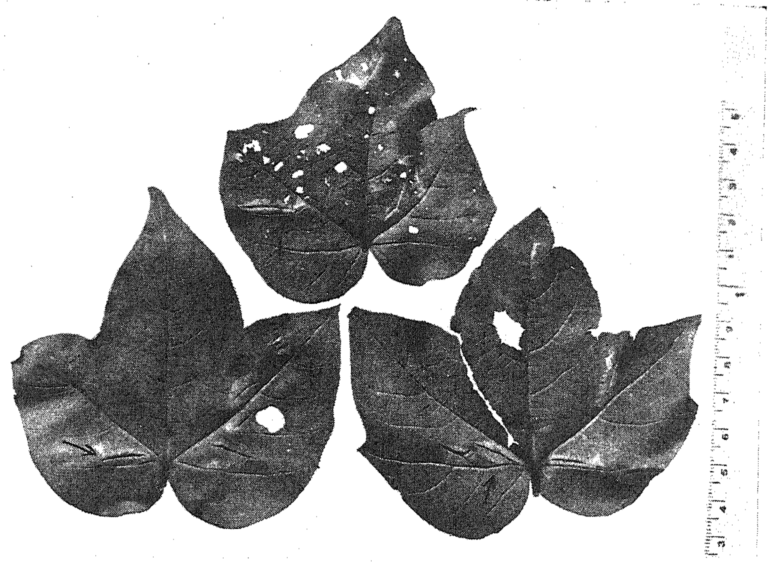

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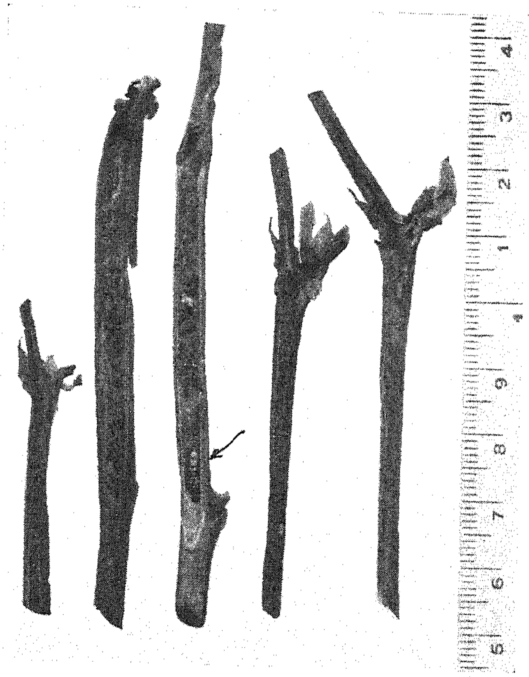

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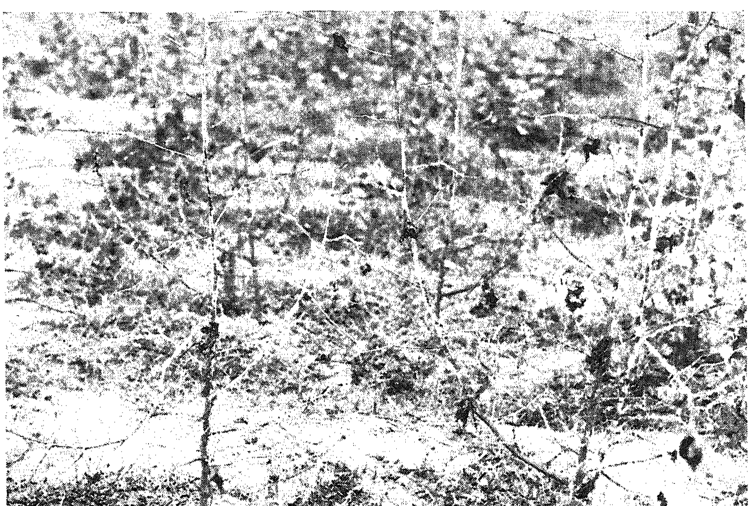

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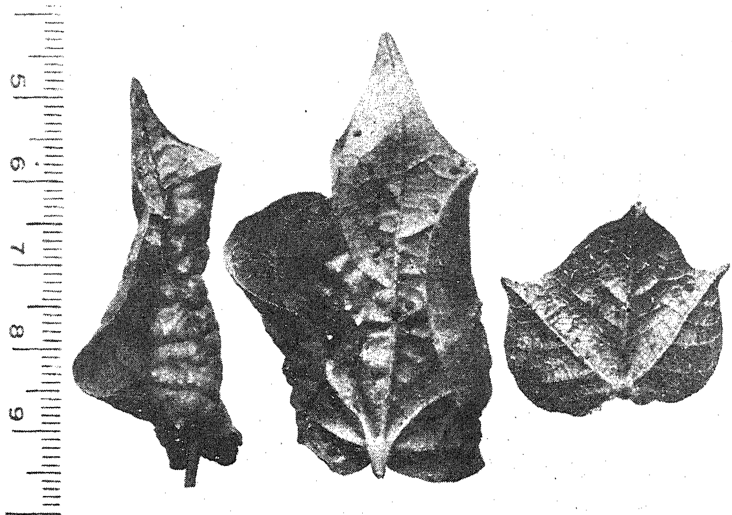

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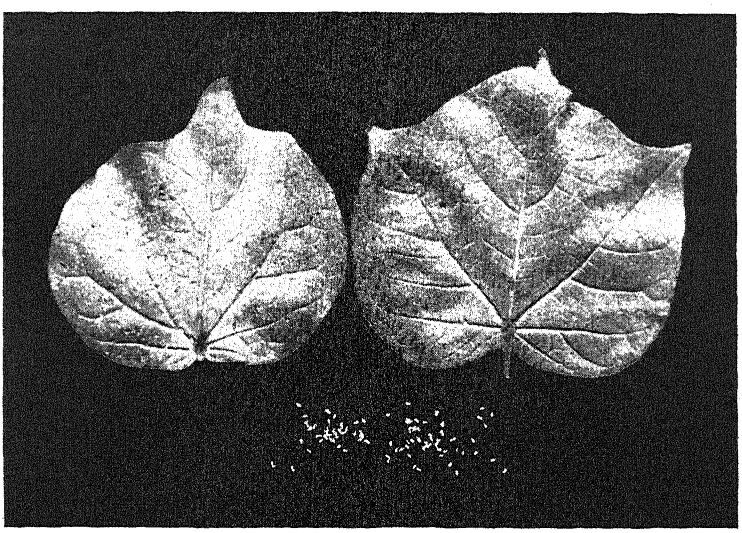

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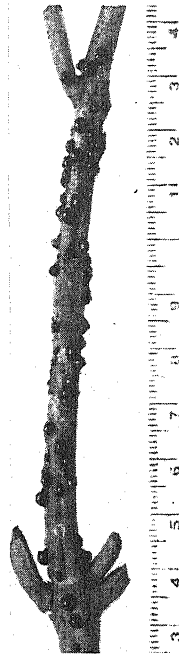

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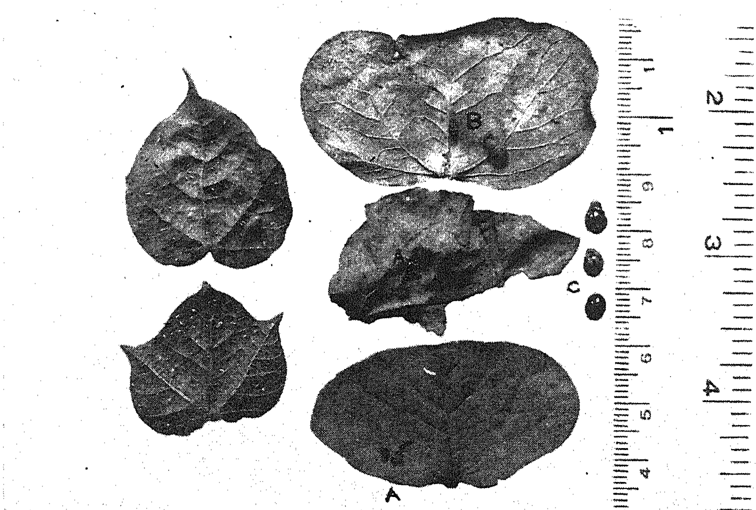

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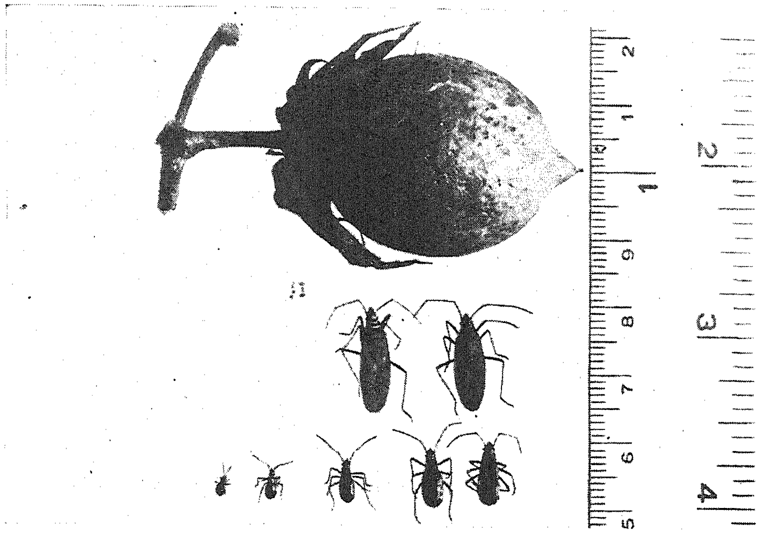

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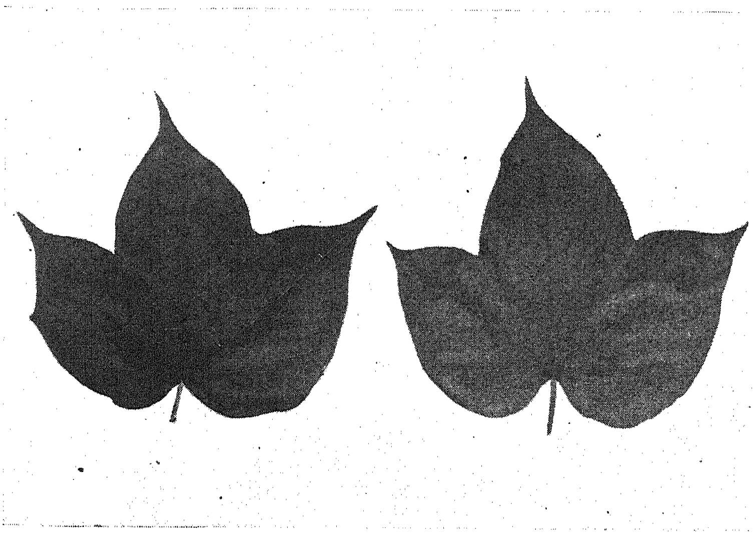

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PLATE 8.

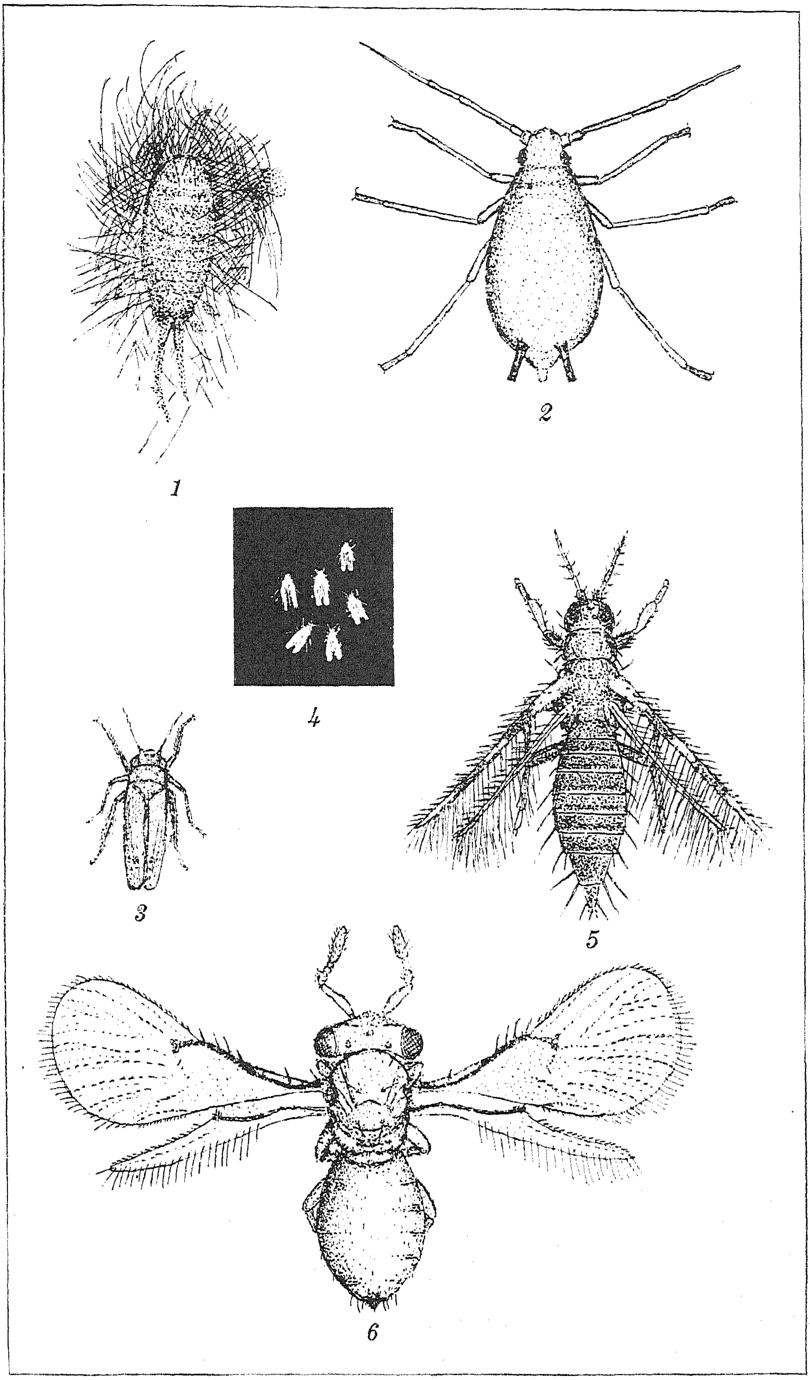

PLATE 9.

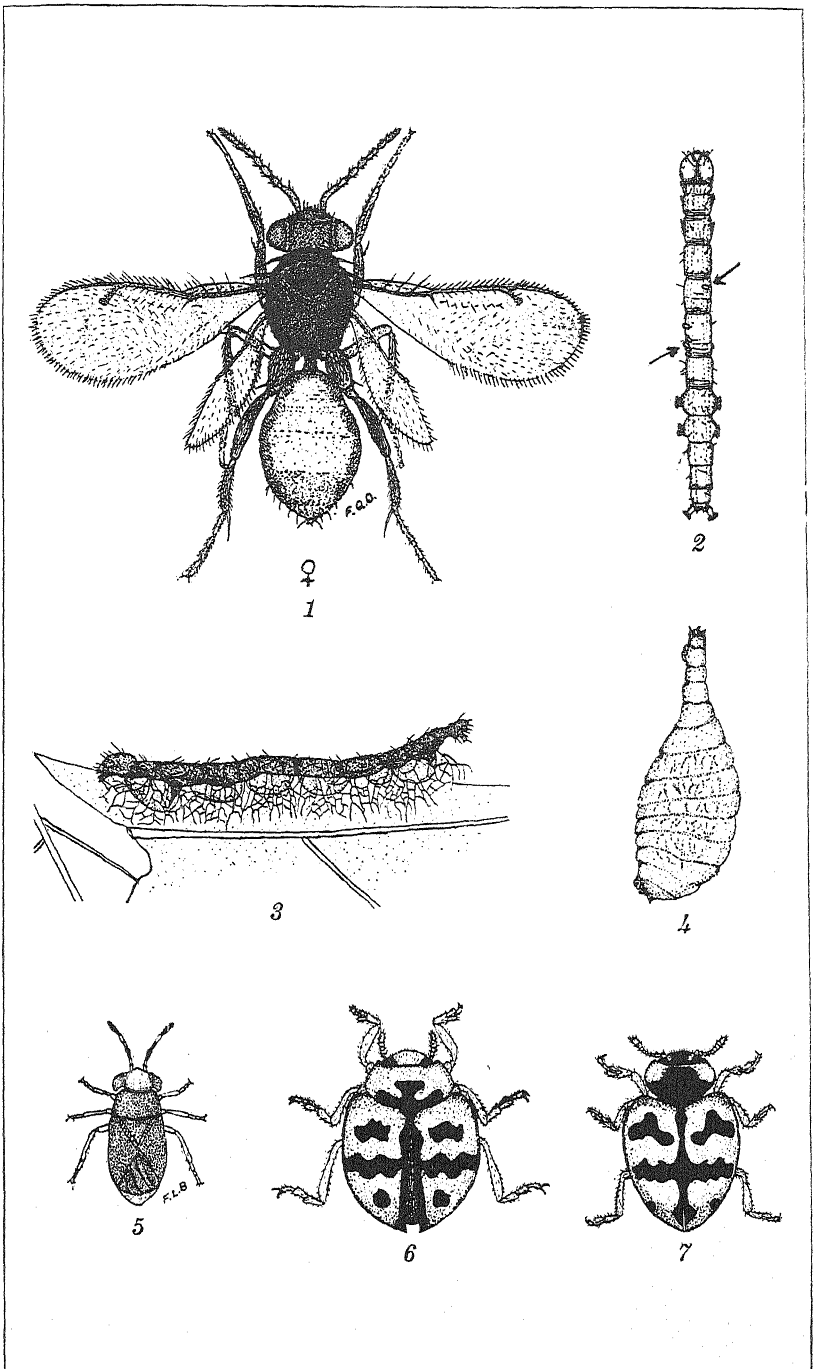

PLATE 10.

BERMUDA ONION[1] (*ALLIUM* CEPA)

By Aniano Elayda

Assistant Agronomist, Bureau of Plant Industry

FIVE PLATES AND ONE TEXT FIGURE

The growing of Bermuda onions is a comparatively new industry in the Philippines, but it has taken hold and promises to be of considerable agricultural importance. Although the native small bulb onions ("sibuyas Tagalog") have been grown on a small scale for a number of years in many localities, particularly Batangas and the Ilocos provinces, it is only recently that we have been fairly successful in obtaining on a commercial scale good crops of the Bermuda onions.

The name "Bermuda" onion derives its name from the Bermuda Islands where it is largely grown for export to the United States. Seeds of this onion are imported from the Canary Islands which are situated on the northwest coast of Africa in latitude 28° North. The climate is subtropical. The Philippines is about 15° North latitude.

Statistics.—The importation of onion into the Philippines from the United States, Dutch East Indies, British East Indies, Australia, Egypt, China, and Japan, is given in Table 1.

TABLE 1.—*Importation of onions into the Philippines.*

Year	Quantity	Value
	Kg.	
1927	7,345,551	₱495,020
1928	10,528,529	695,373
1929	8,985,378	708,146
1930	9,463,319	542,407
1931	13,939,647	624,067
1932	12,059,183	527,281

Varieties of Bermuda onions.—Bermuda onions belong to the mild-flavored group. The three best known varieties are the Crystal Wax, the Yellow (often called the White Bermuda) and

[1] Bermuda onions are commonly called "sibuyas Bombay" in Tagalog.

the Red Bermuda. The Yellow Bermuda is the principal commercial variety. The Red and Yellow Bermuda varieties have already been tried with success in the Philippines and although they have more or less the same yielding quality the Red variety has many objectionable features as a commercial variety, such as brittle dry outer scales; a comparatively high number of splits and doubles; a low percentage of No. 1 onions; irregular shape; and an unpopular color. The Yellow variety is smooth and able to stand much more unfavorable weather conditions.

The Red and Yellow varieties are characterized by flat shape and mild flavor.

Soil, water, and climatic requirements.—The climate most suitable to the proper development of Bermuda onions is both mild and dry. In the Philippines active growth takes place between October and January, the period of mild weather. The planting must take place during this period so that the dry months from February to April may be utilized for maturing the crop.

The Bermuda onion is not suited for planting during the rainy season as it tends to develop vegetative growth at the expense of bulb formation, and rainy weather is not suitable for drying the bulbs, so that shipping and storing cannot be properly done. When the crop is grown under excessive rainfall or too much irrigation, the shipping or keeping quality do not properly develop.

It is very essential that the harvesting and curing be done during March, April, and the early part of May when there are no rains.

It has been observed that Bermuda onions will grow in any kind of soil as long as it is well drained and the moisture content adequate for a period of about two to three months after transplanting, with the only difference that on poor lands the bulbs will be smaller and harder and on rich land bigger and possibly softer, with poorer shipping quality.

An ideal soil for Bermuda onions must have adequate active plant food for ready assimilation, and be porous, mellow, friable, and well drained, but able to retain a proper quantity of moisture. Bad weeds must be absent. Provided the soil is fairly rich and of good texture the use of manure is not necessary in the Philippines as the bulbs have a tendency to grow too big, thick-necked, and to have poor keeping quality.

1. *Selection of land.*—In planting onions on a big scale, the following considerations must be made before selecting the land:

(*a*) Water supply for irrigation and cost of delivery.
(*b*) Risk in handling and marketing a big crop.
(*c*) Is the crop to be grown by dry farming or by irrigation methods?
(*d*) Weed control.
(*e*) Transportation facilities.
(*f*) Labor supply.

If the onions are to be grown under irrigation, the land and location should be chosen with reference to economical and convenient water supply; if they are to be grown without irrigation the land should be situated in an area where the soil is retentive of moisture during the active growing period.

Because of the heavy investment on seeds and labor, the large-scale producer should be certain of production and should foresee and avoid risks in handling and marketing the crop.

Onion farming needs a comparatively large amount of hand labor in planting and weeding, unless the land is free from bad weeds.

As to types of soil, preference should be given to low lying lands along river borders which are predominantly silty loam on account of occasional inundation. This soil is productive without irrigation, but if the water level is too low it requires irrigation to maintain sufficient moisture on the surface for the heavy crops. Alluvial surface soil and clay subsoil evenly admixed with fine gravel but with irrigation, is good soil for this crop. Red sandy soils and darker chocolate loams are good for quick-maturing crops. Places bordering the coasts which have usually dark sandy soils or light sandy soils are good. They are not sticky and can be easily worked.

And soil of the types described above will produce profitable crops under good farming practices.

2. *Preparation of land.*—The land for transplanting should be reduced to a good state of tilth before transplanting. The land should be prepared long before the time of transplanting. When planting time comes the land must be free of weeds, with very fine tilth on top, and compact below.

3. *Kinds of planting materials.*—Bermuda onions may be planted (*a*) by seed, (*b*) by sets, and (*c*) by seedlings.

(*a*) *By seed.*—After the field has been thoroughly prepared and the rows are made the seeds are drilled. The furrows are made shallow with a native plow or a marker. At least 90 grams of seed are sown per 100 meters of row and the seeds covered to a depth of about one centimeter. When home grown seed is not available, this item will be quite expensive. When the young plants have attained a height of about 10 centimeters or have become well established, they are thinned to 10 centimeters apart in the row. Direct planting is not to be recommended on land which is apt to be weedy, as the growth of weeds may choke the young plants and make weeding expensive.

(*b*) *By sets.*—By "sets" is meant small bulbs about one and one-half centimeters in diameter resulting from arrested growth. To produce sets the seeds are sown very thickly on rather poor soil at the rate of 7 to 8 grams per square meter. The young plants cannot develop bulbs fully, due to lack of space and limited moisture; consequently growth is arrested. The sets are harvested, cured, and kept in a cool dry place.

(*c*) *By seedling.*—About six to eight weeks before the young onion plants are transplanted in the field the seed is sown or drilled in the seed bed, whence the young seedlings are transplanted in the field. It is always desirable to transplant stocky seedlings. Stockiness may be induced by clipping back the tops in the seed bed whenever they reach a height of about 15 centimeters. The seedlings are set out in the field with the same distance of rows and of plants in the row as in planting by sets. The most economical way of raising Bermuda onions on a commercial scale is by seedling, known as the transplanting method.

4. *Propagation of seedling.*—Fresh stocks of onion seeds harvested about July in the Canary Islands arrive in the Philippines about September. The time of seed sowing in propagating beds is determined mainly by the prevailing local conditions of a particular region. When the crop is not to be grown under irrigation, the seeds sould be sown early during the September–October period, and if planted under irrigation, sowing as late as the November–December period may be advisable. A hectare of land will require about 3 kilos of seeds and this amount would require a sowing area of 150 to 200 square meters of space.

Friable loamy soil is preferable for seed beds. Heavy soil is objectionable and dangerous as it tends to crack during the germination period of the seeds. The soil should be reduced to a

state of very fine tilth long before sowing in order to remove all weeds. The soil may be sterilized by burning trash on it, restirring the soil and burning trash a second time to kill ants, other insects, and fungi that may be present in the soil. The land should be divided into beds about 120 centimeters wide and raised a few inches above the path. It would be well to allow all weed seeds to germinate before sowing the seeds, because, if the germinating seeds are invaded by weeds, it will be very difficult to weed the plot without destroying and disturbing the tender seedlings.

The seeds should be sown thinly and uniformly and covered with a layer of fine soil about one centimeter thick. After sowing it is necessary to give it a good watering with a spray watering can. The top soil should be kept moist, but if strong continuous rains occur, portable shade to protect it from drying out should be provided. The shed should be removed after the rain, otherwise shading is not necessary.

It is absolutely essential that the beds have the necessary frames and removable sheds in order that when rains come the seedlings can be protected. Afterwards the tender seedlings should be given light watering every day if necessary. Within a week the seeds start to germinate. Before the seeds germinate ants may do considerable damage by eating them. To prevent destruction by ants, powdered rice, corn, or grated coconut meat should be spread along the edges of each bed to attract the ants, and to keep them from destroying the onion seeds. After a month or so, if the soil is rich and is watered when necessary, the seedlings should be ready for transplanting.

The critical stage in the life of the young seedlings is when they are just coming out of the soil. Too much watering encourages growth of damping-off fungus, so that, once developed, this becomes fatal to the seedlings as no remedial measure is practicable. The seed bed should be watered only enough to keep the young plants grow evenly, vigorously and uninterruptedly. A steady, even growth, is very essential for a uniform crop of good onions. To stimulate the growth of seedlings, a dressing of 6 to 8 tablespoonfuls of ammonium sulphate dissolved in a petroleum-canful of water should be applied when the seedlings are two or three weeks old.

If the seedlings grow fast but are tender and slender, they should be clipped back to induce stockiness.

5. *Time of planting.*—Onions being a crop that requires plenty of moisture and warmth, the time to plant them is about the close of the rainy season; that is, during October to November for non-irrigated areas and December to January for places where irrigation is available. The moisture content of the soil should be adequate for at least two months after transplanting. At the time of transplanting the field must be moist and not dry, and if the soil is dry, irrigation must follow soon after transplanting. The beds should be watered at the time the seedlings are pulled up. The seedlings should be clipped 10 to 15 centimeters and should be carried in shaded baskets to the field and then planted as quickly as possible. The plants may wilt soon after transplanting, but as long as they are stocky they will keep on growing. Transplanting can be done any time of the day. But during the hottest part of the day the roots must be soaked in water before planting, as this helps them to recover speedily. Under this condition the seedlings can withstand hot weather.

6. *Depth of planting.*—The proper depth at which the seedlings should be set in the field is very important. Too deep planting is very objectionable as it retards bulbing or will make the bulbs elongated instead of flat or round. If the plants bulb at all when planted too deep, the bulbs are likely to rot, especially in the fields that retain too much water. It would be a good idea to start rather shallow planting, as in the course of cultivating the earth can be thrown toward the plants to cover the bulb region should this be necessary. Where soil remains moist under the surface, there will be no need of throwing the soil to the plants. From 2 to 3 centimeters is about the proper depth at which to set the seedlings. At any rate, covering the axils of the youngest leaves should be avoided. Planted at this depth, the onion bulbs before harvesting are almost on top of the ground before harvest time.

The depth of the furrow should depend upon the moisture content of the soil and the system of cultivation to be employed. If the soil is too moist, shallow or slightly raised furrows should be made, and if the surface soil dries up readily, the furrows should be made deeper.

7. *Method of planting and number of plants per hectare.*—There are different methods of planting to suit the area to be planted, the labor supply, and the irrigated or nonirrigated land; namely, the single-row system for animal cultivation, the bed-system, and the row-bed system for hand cultivation. The

single-row system of planting is carried on shallow or slightly raised ridges about 40 centimeters apart for the hand cultivator and 70 centimeters to 100 centimetres for the animal cultivator. The seedlings are spaced about 10–15 centimeters apart in the row.

The bed-system of planting consists of making a bed about 100–150 centimeters wide and about 10–20 centimeters above the path, the length depending upon the convenience of the planter. The height of the bed above the level of the path should depend upon the texture of the soil; that is, loose soil should have low beds, and heavier soil, higher beds. The path should be of convenient width to be comfortable either for weeding or watering. In planting on a large scale, watering may be done by allowing the water to flow between the beds and to seep through the bed. In this case the paths between beds should be made wider.

The double or treble-row or row-bed system has two or three rows drawn close together by a marker. The rows are 15 to 20 centimeters apart, leaving convenient spaces about 70 centimeters wide between extreme rows, for animal cultivation and for irrigation. This system allows the planting of more seedlings to economize cost of cultivation, irrigation, and weeding.

In growing onions under irrigation, if the row-bed system and animal-drawn cultivation is to be practiced, the rows should be shallow, so that in the course of cultivation the onion bulbs will not be buried too deep by the throw of earth towards the plants. It is sometimes advantageous to plant on low ridges to prevent too deep covering of the bulbs and at the same time drain off excess water.

The estimated number of bulbs and weight per hectare is shown in the following table:

System of planting	Distance	Number of bulbs less 12 per cent loss	Weight in kilos at 15 bulbs per kilo
Single row	40×10	220,000	14,666
Double row	70×10	220,000	14,666
Do.	80×10	195,360	13,024
Treble row	80×10	264,000	17,600

8. *Cultivation.*—The field can be cultivated either by hand or with a fine-toothed cultivator drawn by an animal. Weeds

should never be allowed to gain a foothold, for the onions can never amount to anything if the land is allowed to grow weeds. Hand weeding should always be resorted to. Hand weeding being very tedious, the cleaner the land is made before planting being very tedious, the ileaner the land is made before planting the lower the weeding bill will be. Two or three thorough weedings are enough to check the growth of weeds.

Onions are very shallow feeders, so that the mass of roots grow near the surface of the soil. Hence, sallow cultivation should be done frequently to keep a soil mulch and avoid baking and cracking. After irrigating the field it is very essential to keep the surface soil stirred. Whether the planting is in single, double, or treble rows, the same principles apply; that is, cultivation is needed after irrigation to maintain uninterrupted growth. The soil should always be cultivated slightly toward the onion plants so as to keep them covered with a thin soil mulch. The bulbs should never be covered thickly during cultivation as that may induce rotting, especially if there is too much moisture in the soil.

9. *Fertilization or manuring.*—Soil of proper texture which may be either loamy inclined to be silty or sandy loam, and of average fertility, does not have to be manured, lest it produce onions which are too sappy and thick-necked and of poor keeping quality. Manure applied to soil where it is not needed will only make the soil very porous. However, clayey soil that hardens on top will grow onions when manured adequately so as to make the top soil friable when dry, provided it is well drained. Manure should be applied in quantities from 5 to 10 tons per hectare. It may be hauled to the field and spread as uniformly as possible on the surface and then plowed in afterwards.

On poor land the use of ammonium sulphate as a top dressing at the rate of about 150 kilos (20 per cent N) per hectare will be beneficial.

10. *Irrigation and watering.*—Water is the principal determining factor of success in the raising of profitable onion crops. In order to obtain a good crop of onions the soil region where the root system is distributed should be moist but never with standing water during the active development of the plants. This period continues for two months after transplanting.

The root system being shallow the plant has not the power to grow deeply to reach the moist layers of the soil; so that even rich soil with a deep moisture level would grow on unsuccessful

crop. Soil conditions favorable to corn, peanuts, or tobacco would suit onions well, provided soil moisture is ample.

In irrigating an onion field, two essential factors should be considered: (1) to keep the soil well supplied with moisture but not to allow standing water continuously, and (2) to cultivate, particularly after irrigation, as soon as the surface soil permits in order to conserve moisture and prevent cracking and baking. The frequency of applying water must be timed to produce economically a crop of good keeping quality. Improper application of water will destroy the keeping quality for the reason that too much water applied untimely will induce the plants to develop big-necked onions and retard the maturation of the crop. In the light of past observation, four to eight irrigations during the growing period of about seven to eight weeks after transplanting should be enough. After this period, the plants should have fully developed foliage with fair-sized bulbs. Toward the period of maturity little or no water is needed as there is danger of starting a new growth, but the surface must be kept well pulverized.

To irrigate, the water must be run in shallow furrows between the rows of onions or in paths between the beds and allowed to seep into the rows or through the beds. Undue flooding heaps the earth around the plants and buries the plants deeper than is desirable. To apply water uniformly the land must be level, and if the soil is porous, the rows or furrows and beds should not be unduly long.

11. *Maturing, harvesting, and curing Bermuda onions for the market.*

(*a*) *Maturing the crop.*—The first indication of ripening or maturity is in the condition of the necks of the plants. When the necks are shrivelled or softened and the tops have fallen, even though some of the tops may yet be green, the crop may be harvested. The entire crop may be harvested if about a third of the tops are down and most of those standing have softened necks. Owing to unevenness in the soil, some patches will drop earlier, others later. Hence, judgment must be exercised and the best average condition of the maturity of the crop determined. It is, however, preferable that the individual plants which have shown indication of maturity be harvested daily. When the onion begins to dry up gradually from the tips of the leaves down to the neck, and the neck remains rigid and firm,

an abnormal process of ripening si taking place. This condition makes for poor curing and keeping qualities. Onions maturing in this manner should be separated from the stock and marketed promptly during the harvesting period.

Maturing onion bulbs should never be permitted to start a second growth once they are well bulbed to fair commercial size, otherwise their curing or keeping qualities are ruined. Heavy rains and excessive irrigation may easily induce second growth in an onion crop already beginning to mature, so that irrigation should be done with great care after the bulbs have reached fair size.

(*b*) *Harvesting.*—Onions which have shrivelled or softened necks or fallen tops should be harvested. In harvesting, the onions should be dug or pulled off gently in order not to break the dry scales of the maturing bulbs. When onions are dug and clipped too green, or before they have been permitted to lie in the sun for a day or so to cure and dry, the bulbs may force out their central buds again as if starting a second growth. Bulbs which have started to grow for the second time should be culled and cured again. If the onions have fully matured and dried in the field, they should be clipped at once. These onions can be crated and marketed without further curing.

Green or moist onions should never be crated because they decay quickly. They should first be properly spread and dried before sorting, packing, and loading. The tops should be clipped to about one-half inch stubs. If the necks show much sap when clipped, the bulbs should by all means be left in the open to cure well at the stubs. This will insure better keeping qualities especially during warm humid days. Care must be taken during exceedingly bright sunny days that the onions are kept in the sun just a few hours and then brought to the curing shed out of the direct heat.

(*c*) *Curing.*—From the field after a day or two of exposure to sunshine, the onions should be hauled to a house or shed (a roofed shed open at the sides and ends) where they should be laid on racks made of wire or bamboo, preferably the latter, or else placed on a dry straw-covered floor. The bulbs should not be heaped. Care should be taken that the shed admits a good current of air. In a week or so the tops will be quite dry and the onions will have a tough dry skin on the outside which will protect the bulbs. The tops should be pulled off or cut with a knife if they are thick-necked. The bulbs are ready to pack

in crates for the market. In clipping or twisting the tops, a stub about two to three centimeters long should be left to avoid the exposure of the succulent tissue of the fleshy scales of the bulb. Care should be taken to avoid bruising the bulbs and thus opening the way for organisms which cause decay.

Another way of curing onions on a small scale is to plait the tops into a rope and hang up the bulbs in a dry airy cellar or roofed shed. The onions cured in this way may keep up to five or six months. When the onions are thoroughly cured and dried they may be shipped with safety.

(*d*) *Construction of the shed.*—The capacity or size of the shed should, of course, depend upon the size of the harvest expected from the planting.

The principal points to be considered in building a shed are (1) maximum ventilation, (2) safety of the bulbs from pressure due to heaping, and (3) ease in handling the onions. To obtain these, (1) all sides should be open, (2) shelves made of

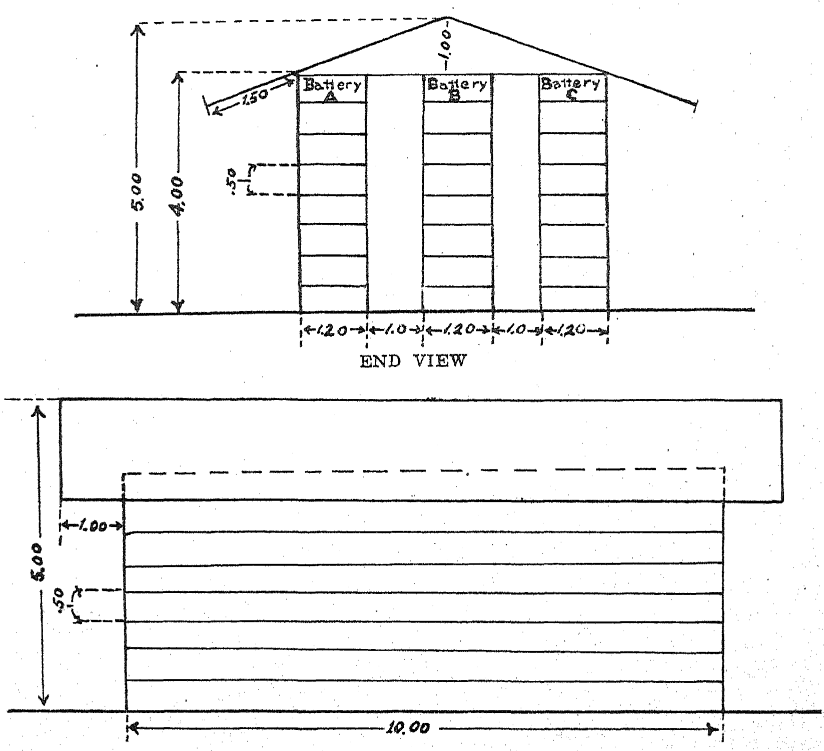

FIG. 1. Curing shed calculated to have a space of 864 sq. m. for drying. It will hold from 15,000 to 20,000 kilos of onion bulbs. Batteries A,B,C, are shelves 120 cm. wide running longitudinally along the shed with 50 cm. each way down and above the others.

either wire netting or split bamboo should be constructed, and (3) there should be aisles between the batteries of shelves from which the worker can reach the middle of these shelves. (Text fig. 1.)

ONION PESTS AND DISEASES

In Batangas regions growing small-bulb onions (sibuyas Tagalog), a certain malady locally known as "Pasik" is widespread. It is prevalent mostly during February. The soil planted to this crop is infested with this malady. Bermuda onions planted on fields that are infested or near the plantings of small bulb onions were observed to be infested with a similar malady.

The appearance of infested plants is very striking. Single plants or groups may be affected. The most characteristic development is in definite spots of irregular size and varying area in which the plants appear whitish and dry from a distance, owing to the absence of coloring matter in the leaves. A field with advanced infestation has the appearance of being partly burnt over. Where the plants partially recover, they remain dwarfed or stunted and bushy. Occasional plants may be found to remain healthy even in the midst of the most infested spots. This infestation described in general was caused principally by thrips (*Thrips tabaci*) and was found to be associated with many other troubles, as follows:

Leaf-mold (*Black stalk rot, Macrosporium parasiticum*).—Practically all the stalks or leaves broken off at girdled area with the free and dry portion near the ground still green were affected. Under moist conditions the disease produces black mold on the dead tissues of the leaves. The fungus attacks the leaves of onions independently or following a disease known as mildew. In the latter case, the damage is quite serious.

Mildew or blight (*Peronospora schleideni*).—The attack occasioned by this disease is quickly followed by the black stalk-rot and therefore cannot be recognized readily. Plants attacked by mildew and not overrun by black mold or black stalk-rot show the characteristic symptoms of the disease, which at first appears as a violet, furry covering on the outer surface of the leaves. At a later state the leaves become pale green and finally yellowish. Under this condition the dead leaves appear blighted, the growth of the plants is reduced, and as a consequence the bulbs remain small.

The spores of *Macrosporium* and *Peronospora* fungi causing leaf mold and mildew are easily carried by the wind to healthy plants and in damp weather drops of water on the plants furnish sufficient moisture for their development. This growth of the fungus penetrates the tissues of the plant and absorbs food from it, causing the leaves of the onion plants to shrivel and die. This fungus hibernates in the diseased leaves and soil and becomes active during the next planting season and again starts the disease in the new crop.

Bulb rot (*Fusarium zonatum*)—This disease is recognized by the characteristic yellowing and dying back of the leaves from the tips. When plants suffering from this kind of malady are pulled up the roots of those newly infected show weakness at the beginning of the rot, whereas the bulbs of those in an advanced stage of the disease show a semi-watery decay advancing from the base of the scale upward. Under this condition the bulbs are soft and slimy to the touch. The presence on the affected tissues of the bulbs of such other organisms as the nematodes and bacteria hasten the decay of the bulbs. Maggots may also be present in the decayed bulbs but they are known to cause only slight damage.

CONTROL MEASURES

Because of the nature of the diseases attacking Bermuda onions in fields planted to small-bulb onions or near plantings of the small-bulb onions, the following measures will be found helpful in controlling such diseases:

1. *Sanitation.*—When infection has just started, the spread should be prevented by pulling the plants and burning them right on the infected spots.

2. *Spraying.*—Bordeaux mixture or dusting with sulphur powder or copper lime dust once a week to obtain effective results may be used.

3. *Soil sterilization and crop rotation.*—Since the fungi causing onion diseases hibernate in the soil, it is advisable to practice long crop rotation in infected fields and soil sterilization by burning dried grasses or trash on the plots before planting. This is specially advisable in seed beds. This treatment should involve plenty of burning and stirring the soil with a rake. The ashes may be raked during the final preparation of the soil.

4. *Time of planting with relation to control of diseases.*—There is observed to be a slight damage to young plants; therefore planting should be timed so that by February the bulbs are already big.

Smut (*Urocystis cepulae*).—Dark pustules appear within the leaves or scales and may split open, exposing black powdery masses, principally on the young seedlings.

Fusarium rot (*Fusarium* spp.).—A rapid dying back from the tips of the leaves, accompanied by a rot starting at the base of the bulbs.

White rot (*Sclerotum cepivorum*).—A condition of the tops quite similar to Fusarium rot but differing in that round dark brown bodies appear in the diseased bulbs.

Pink rot (*Fusarium malli*).—The roots turn pink and die; new roots are attacked as they develop, resulting in a marked stunting of the plant.

Rust (*Puccinia porri or P. asparagi*).—Orange or golden yellow pustules appear on the leaves or seed stems, especially on those of the Egyptian onion.

Dodder (*Cucusta* sp.).—A creeping or twining, leafless plant attacks leaves of onions, often killing the tops in roughly circular areas in the field.

Root-knot (*Heteroders radicicola.*)—The leaves become a sickly green; swellings form on the roots.

Thrips (*Thrips tabaci* Lindeman).—Small white chafed spots appear on the leaves causing them to die prematurely; the minute pale-yellow thrips which cause the injury are commonly present.

Onion maggots often kill seedlings by feeding on the roots.

DISEASES IN STORAGE AND IN TRANSIT

Neck-rot (*Botrytis* sp.).—A rot begins at the neck of the bulb and progresses downward; the tissue shrinks and collapses; a gray to brown moldy growth and hard, black kernels later appear on the surface of the affected scales.

S*oft-rot.*—A rot that begins at harvest time or later, but differs from neck rot in that it is softer and more watery, usually with a very offensive odor.

Fusarium rot (*same organism as that in the field disease*).—A semi-watery rot advancing from the base of the scale upward.

Black molds (*Aspergillus niger*).—Black, powdery masses form, not in definite pustules within the scales, as in smut, but on the outer surface of the scales or between them.

Smudge (*Collectotrichum circinans*).—Smudgy, superficial black spots made up of fine dots, but with no powdery masses, appear shortly before harvest time on the outer scales; primarily on white varieties.

Mold (*Macrosporium porri*).—A semi-watery decay, at first deep yellow, then wine red and finally black, attacking the neck or wounds in the scales, which dry down in a papery texture.

ECONOMICS OF ONION PRODUCTION

TABLE 2.—*Estimate of cost of production by the field or row-method of culture (not including land tax and interest on investment and depreciation) on one hectare of land.*

Items of operations	One hectare		
	Man days	Animal days	Cost approximately
1. Cost of seeds, 4 kilos	--------	--------	₱48.00
2. Seed bed preparation and sowing	6	--------	6.00
3. Care of nursery (watering, making of shades, disinfection, thinning, etc.)	60	--------	30.00
4. 1st plowing	7	7	10.50
5. Harrowing	2	2	3.00
6. 2nd plowing	5	5	7.50
7. Harrowing	2	2	3.00
8. 3rd plowing	5	5	7.50
9. Harrowing	2	2	3.00
10. Furrowing	1	1	1.50
11. Transplanting	30	--------	10.00
12. Cultivation (5 times)	2	2	15.00
13. Weeding (4 times)	30	--------	48.00
14. Irrigation charges (Government charges)	--------	--------	12.00
15. Furrowing (4 times)	1	1	6.00
16. Harvesting, Stacking and Curing	6	--------	6.00
17. Hauling	3	3	4.50
18. Packing	--------	--------	14.00
19. Crating	8	--------	8.00
Total	--------	--------	243.50

Cost of production per kilo as per above figures:

At 7,000 kilos per hectare	₱0.035
At 8,000 kilos per hectare	0.031
At 13,000 kilos per hectare	0.091
At 14,000 kilos per hectare	0.017

Based on the 1929 importations of onions, the average wholesale price per kilo is approximately ₱0.06. Thus there will still be realized a reasonable net profit from the minimum yield of 7,000 kilos per hectare.

TABLE 3.—*Cost of production by intensive culture (excluding land tax and interest on investment and depreciation) of one hectare of Bermuda onion plantation with irrigation, grown during the 1933–34 planting season.*

Items of operation	Cost
1. Cost of seeds, 2.5 kilos at ₱8 a kilo	₱20.00
2. Preparation of seed beds and sowing, 200 square meters	43.50
3. Care of nursery	7.50
4. 1st plowing	12.00
5. 1st harrowing (including lifting of weeds and throwing them away, etc.)	24.00
6. 2nd plowing	12.00
7. 2nd harrowing	12.00
8. 3rd plowing	12.00
9. 3rd harrowing	12.00
10. Preparation of field for planting (bed system)	37.50
11. Transplanting (including lifting of seedlings, distribution of same, watering, etc.)	90.00
12. Irrigation, 3 times	22.50
13. Weeding and cultivation, 3 times	37.50
14. Harvesting	7.50
15. Hauling, cutting of leaves, drying in sun curing, etc.	82.50
16. Crating, etc.	7.50
Total	440.00

This project was done under the administration of an experienced Bermuda onion planter. The expenses incurred in some of the items are quite high. In the preparation of seed beds a big amount was spent as the land was infested with persistent weeds. The thoroughness of the preparation of the seed beds was manifested by the very low amount spent in their care. The first harrowing was also expensive as the roots of weeds had to be gathered thoroughly. Transplanting, including pulling of seedlings and distributing them in the field and watering the newly transplanted plants by the bucket system, was laborious and hence quite expensive. A big amount was likewise spent in item No. 15 because the process of drying the onions in the sun repeatedly and curing them without the use of curing sheds and separating rotten from good onions, necessitated plenty of labor. This was done to insure good keeping quality. Laborers were hired at ₱0.50 per day and plowmen at ₱0.80.

A crop of 18,900 kilos was obtained from this farm. The wholesale price at the farm was ₱0.06 per kilo, while prices in Manila ranged from ₱3.20 to ₱3.70 per sack of 40 or 45 kilos.

By the tenant system of raising onions, even if prices are much lower than herein given, under favorable conditions both the land owner and the tenant will have a good margin of profit. The flooding of the markets occasioned by the importation of cheap onions from Japan may prove disastrous to onion planters in the Philippines, but due to high yields grown under favorable conditions, it may be safely concluded that onion growing should bring a reasonable margin of profit. The fact is herein emphasized that the Bermuda onion has a better eating quality (although quite inferior in keeping quality) than the common "strong" onions ("sibuyas Bombay") imported into the Philippines.

REFERENCES

ANONYMOUS, Onion Diseases and Their Control. U. S. Department of Agriculture. Farmers' Bull. No. 1060.

ANONYMOUS, Onion Culture, U. S. Department of Agriculture. Farmers' Bull. No. 354.

ILLUSTRATIONS

PLATE 1

FIGURE 1. A Yellow Bermuda onion field showing the system of single row planting and cultivating by animal drawn cultivator.

2. The same field in Figure 1 showing the close-up view of double row planting. Note the furrows between the double rows which served as irrigation canals.

PLATE 2

FIGURE 1. A group of Yellow Bermuda onion plots planted directly by seeds.

2. A Yellow Bermuda onion plantation planted by seedlings in plots. Weeding and cultivating were exclusively done by hand labor and the paths between the plots served as irrigation canals.

PLATE 3

FIGURE 1. A Yellow Bermuda onion filed showing the growth and development of bulbs on sandy loam soil along the seashore.

2. Bulbs of Yellow Bermuda onion showing the formation of the proper size of neckstems—a characteristic of good curing.

PLATE 4

FIGURE 1. Bulbs of Red Bermuda onion showing the formation of thick neckstems—very objectionable for proper curing.

2. Abnormal development of Yellow Bermuda onions caused by a malady locally known as "Pasik." The primary attack is caused by Thrips (*Thrips tabaci*) and the secondary attack is caused by several fungi.

PLATE 5

FIGURE 1. A view of freshly harvested onions spread thinly on the ground for sun curing.

2. A view of sun cured onions preparatory to sacking.

TEXT FIGURE

FIGURE 1. Curing shed calculated to have a space of 864 square meters for drying. It will hold from 15,000 to 20,000 kilos of onion bulbs. Batteries A, B, and C, are shelves 120 cm. wide running longitudinally along the shed with 50 cm. each way down and above the others.

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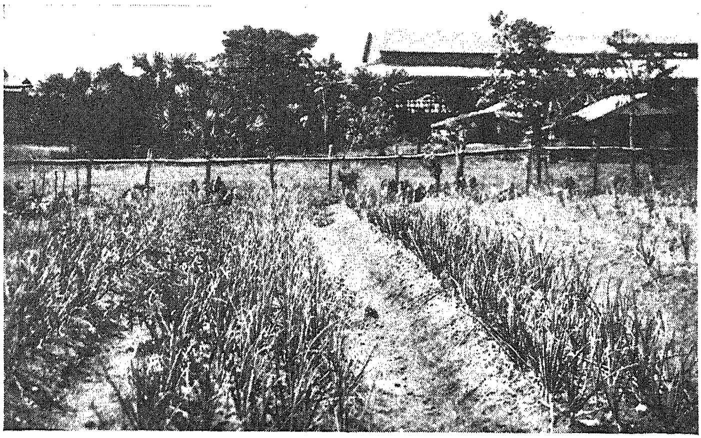
PLATE 1.



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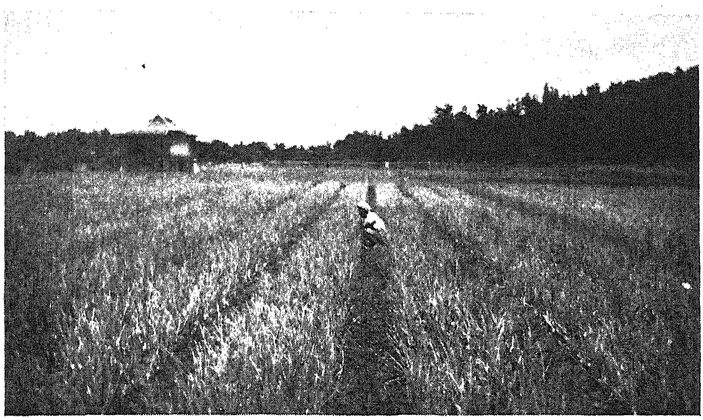

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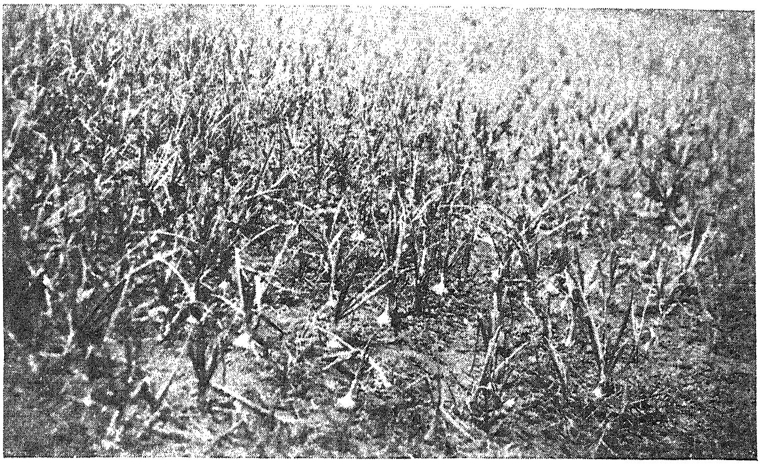

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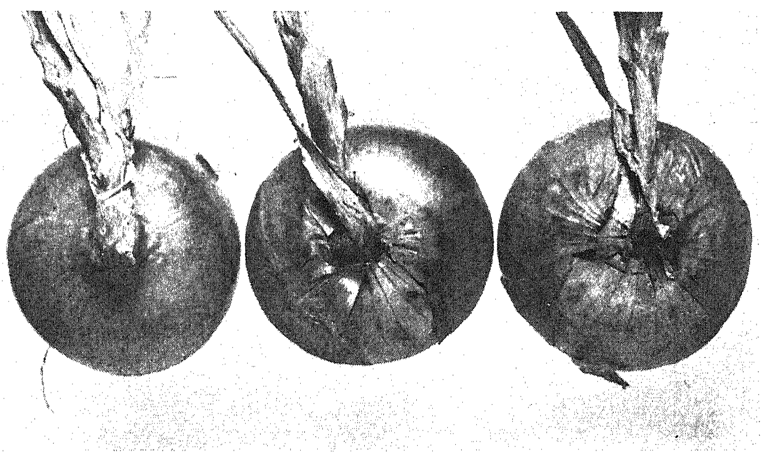

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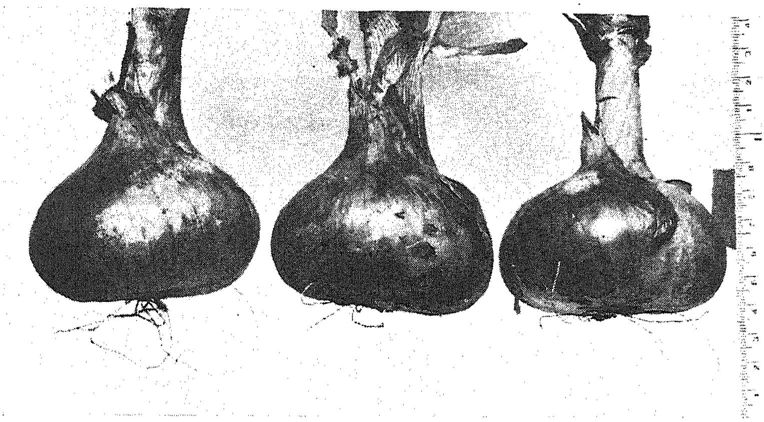

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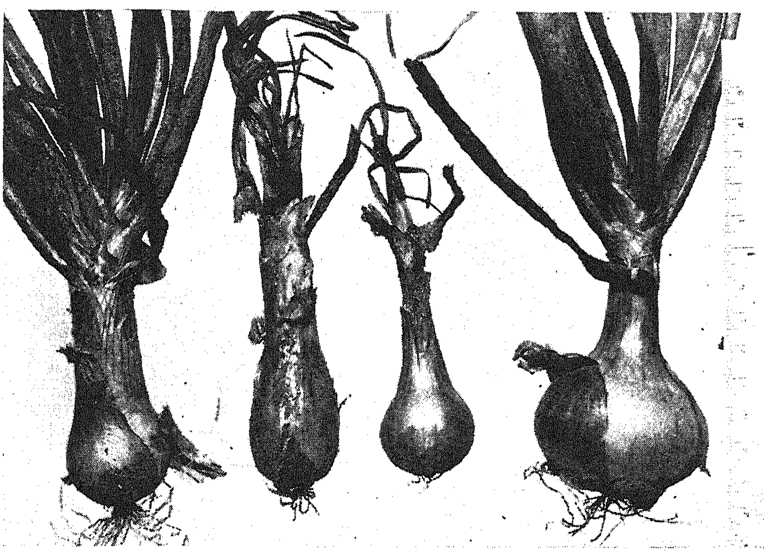

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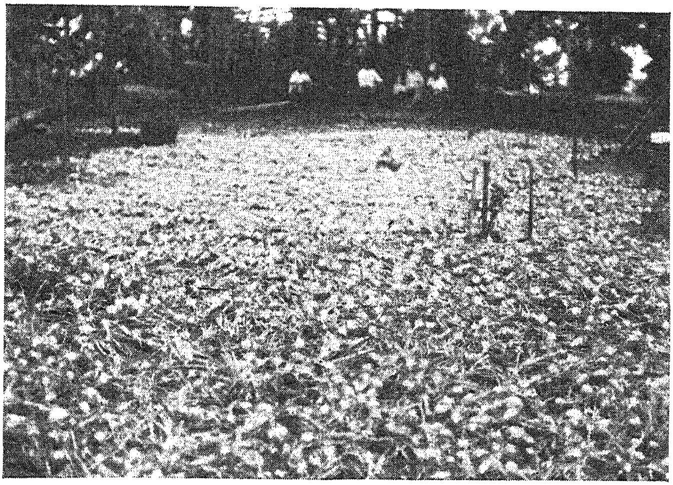

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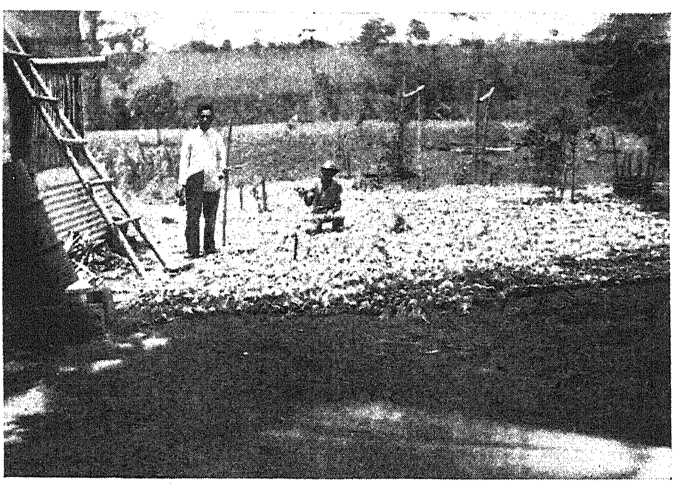

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PLATE 5.

EFFICIENCY OF CITRUS ORCHARDS IN TANAUAN CITRUS STATION

By JUAN P. TORRES and FAUSTINO MARAJAS
Of the Bureau of Plant Industry

The Batangas mandarin, *Citrus nobilis* Lour., which is commonly known as *Sintones* or *Dalanjita* in Tagalog, *Lulukisen* in Ilocano, is the most important citrus species in cultivation in the Philippines. It has been and is extensively grown in the Province of Batangas. To give credit to the province which gives this mandarin commercial importance, it is but fitting to name the variety "Batangas mandarin." In some recent literature on *Citrus* in the Islands pertaining to mandarin, this name has been used to designate this particular variety. Batangas mandarin was introduced into the Islands very long ago. There is great similarity between Batangas mandarin and Suntara (*P. I. No. 1262*) which was introduced in 1912 from Saharanpur, India. In 1912, Tanaka(6) identified Ponkan, *Citrus poonensis* Hort. ex Tanaka, with Suntara, an orange of Poona. Our Ponkan, *P. I. No. 9897*, introduced from Tiapeh, Formosa, Japan, in 1927, has not yet fruited, but in stem and leaf characteristics it is more or less similar to the Batangas mandarin. It may be possible therefore to identify the Batangas mandarin with Ponkan and Suntara. The traders in early days may have brought this variety into the Islands directly from India, although many investigators believe that it is indigenous to Cochin-China.

The Batangas mandarin may be considered superior in eating quality to most other mandarins recently introduced and grown in the Philippines(8); the late Horticulturist P. J. Wester so regarded it(1).

The most common method of propagating *Citrus* in the Philippines is from seeds. Being a genus with species and varieties that are so generally heterozygous(2, 3) and propagated from seeds, it is to be expected that variation in yields, types and qualities of fruits, types of trees and fruiting habit, should be common. This being so, old orchards in the Philippines should offer excellent material for the selection of superior trees.

Prior to this report there has been no selection of productive Batangas mandarin trees based on individual performance, as there were yet no data. The Government had to content itself either with owners' statements about their trees, or with one or two years' casual observation of bearing trees, budsticks from trees believed to be superior being then collected for propagation in the Government stations. In this way some twenty-three strains have been isolated at the Tanauan Citrus Station. Of this number, two seemingly superior or rather promising types, *P. I. No. 8865* and *P. I. No. 8868*, have been extensively propagated and were recommended for commercial planting(4) until some more productive trees can be found by judicious selection.

Important bud- or branch-mutants are very seldom found in the Batangas mandarin. From several thousand trees in the station and vicinity, observed during the last fifteen years, only one branch-mutant, from tree *B298*, has been isolated. It produces fruits of excellent quality, is early bearing, and its branching is very much improved as compared with the common type. This particular mutant, judged by the mother tree, as well as by its buds topworked on other old trees, has proved to be a regular bearer.

OBJECT OF THE PRESENT STUDY

This study was undertaken for two purposes; first, to determine the efficiency of the different orchards of the station, consisting of trees grown from seedlings, and second, to select on the basis of ten-year production, (1924–1933, inclusive), a number of high-yielding trees from which to get budsticks for commercial propagation. High productivity is here considered of paramount importance, although other important characteristics, such as size, uniformity, and quality of the fruits, are not to be overlooked in the process of selection.

MATERIALS AND METHODS

The trees in the orchards under consideration were about eighteen to twenty-three years old when they were acquired by the Government in July, 1919. These trees, according to information, were fruitful prior to the eruption of Taal Volcano on January 29, 1911. After that incident, the combined effects of a long dry season in 1911 and the prevalence of bark-rot disease, together with poor orchard management, reduced the production of fruit to nil. Most of the trees within and near

the station suffered very severely and many of them died. Many citrus groves were wiped out entirely.

When the Government acquired these orchards, they were wholly neglected; weeds, shrubs, and wild trees were abundant. The surviving citrus trees were sickly and covered with *Loranthus*, a plant parasite.

The identity of each tree was first established. Three orchards were designated A, B, and K, and the trees in each were numbered, as A-1, B-1, K-1, and scattered trees were given the initial letter S. Numbers were painted on the trunks with lead paint facing in one direction, about 1.5 meters above the ground.

General clearing was done as fast as possible, and clean cultivation was then maintained. Catch crops of rice and corn were grown in rotation with some leguminous crops. Close observation of the health of the trees for about three successive years showed that clean cultivation and cropping did not improve their condition; much to our surprise, many trees continued to die, in spite of good care and practical control of diseases.

Common local experience with the Batangas mandarin was that these trees were quite indifferent to constant cultivation, therefore it was the local practice to allow the citrus orchards to run to grass and weeds of all sorts. Madre cacao, *Gliricidia maculata*, was sometimes used as shade for citrus; and was allowed to grow too high, thus impairing the health of the citrus trees.

The station, therefore, turned its attention to the use of permanent cover crops, only modifying the old practice. Legumes were used as cover and green manure crops. Cover crops were not allowed to grow too tall, but were cut at frequent intervals so as not to shade the citrus trees but to furnish abundant green manure. Early in 1923 Orchard A was planted partly with *Tephrosia candida* and madre cacao, Orchard B with madre cacao alone and Orchard K with ipil-ipil, *Leucaena glauca*. After a little over a year of this treatment the trees were recovering rapidly, and several trees started to produce good crops in 1924.

Trees in the orchards were planted in regular rows, about seven meters apart. The scattered trees, however, are mostly along the road and in off-places in the newly established orchards. Orchards A and B are more or less rolling and easily drained, and the soil is of medium sandy loam and rich loam soil enriched annually by soil debris from neighboring higher lots. At the beginning of the experiment in 1924, Orchard A contained

114 trees, Orchard B, 328 trees; Orchard K, 57 trees; and there were 123 scattered trees.

Beginning November and December, 1929 a complete fertilizer was applied regularly to all orchards, including scattered trees, at the rate of two kilograms per tree per year. Three years after, instead of a single dose, two applications of one kilogram fertilizer to each tree were made, beginning at the close of the rainy season, October and November, 1932, while the trees were in fruit; and the second half-dose was applied in the early part of the rainy season, April and May, 1933.

Collection of yield.—The yields of individual trees were gathered in two counts. At first the estimate was made three to four weeks before maturity, and in the second, the actual number of fruits was taken at harvest. In estimating the yield of a tree the procedure depends upon the size of the crop. The fruits are actually counted when the tree bears about five hundred fruits or less. A heavier crop is determined by first quartering the tree and then counting the number of fruits in one quadrant only, if the branches are more or less uniformly loaded. The number of fruits thus obtained is multiplied by four. In case the fruits are unevenly distributed in the tree the fruits in two quadrants representing half of the whole crops are counted, and the count obtained is multiplied by two. Two estimates are taken on the same day and the average of the two determinations is considered the estimated yield of the tree for that year.

The actual count of fruits at harvest is corrected whenever necessary and is considered the yield of the tree for the year. In case for some reason or other the number of fruits at harvest cannot be obtained, as in 1931, the estimated yields are used as final.

In spite of the fact that there were trees which in some years have produced very heavy crops, no thinning was practised during the last ten-year trial. Generally during and after high winds more damage is done with a lighter than with a heavier crop. As the trees grown from seedlings were not trained or pruned low, they generally grow very tall, and as the fruits are easily detachable from the stem—a poor characteristic of the variety(8)—they are indeed very susceptible to windfall. Unless the orchards are adequately protected from high winds by means of windbreaks, thinning of young fruits from heavily loaded trees would seem not very advisable.

The number and percentages of bearing and nonbearing trees every year, and the average yearly production, are presented in Table 1. Table 2 gives the number of trees that have survived the test and their distribution according to their yielding capacity, based on total fruit production for ten years.

Table 3 shows the production of the 32 highest-yielding trees from the different orchards; 10 trees of Orchard A, 9 trees of Orchard B, 11 trees of Orchard K, and 2 of the scattered trees.

A method of comparison based on the ratio of individual yields to the average yearly production of bearing trees in their respective orchards is also presented. The relative yield ratios, and their averages, are shown in Table 4.

GENERAL REMARKS

Before discussing the results it is of interest to consider the relation of climate to citrus production. Climate plays an important rôle in the production of Batangas mandarin, as experience has shown that, although it requires a certain amount of precipitation for the normal vegetative development and fruiting of citrus in non-irrigated areas and far from the lake shores, there is a climatic deviation that is considered favorable for the production of a normal crop. This plant needs, after the rainy season, a period of warm days with a short dry spell in order to insure a heavy blooming. Thus, when warm days start early in January extending through February and then a heavy rain falls in March, the fruiting season for the year will be quite early. On the other hand, if cool days continue well into February followed by warm days in March and April and then with a heavy rain late in May or June the resulting crop will be a late one. Heavy rainfall in April after a period of warm days is conducive to heavy blooming with a resultant good crop.

Constant showers and cool days throughout the winter and spring months are unfavorable to flower production. Instead, most of the trees undergo vegetative development, with the result that the crop becomes very light or practically nil. Such weather occurred in 1928 and was followed by an abnormally small crop. Likewise, in 1932 and 1933 the weather was not very favorable to citrus production, for the cool days lasted well into the spring months; nevertheless the crops in those years were larger than that of 1928.

Another point of interest to be considered in this connection is the fact that the crops during the first five-year period were smaller than during the second or last five years. Several possibly responsible factors may be mentioned, but it is not possible to show the degree of influence exerted by each of them separately.

During the first period, the trees were in the process of vegetative recovery from the effect of heavy root pruning caused by previous clean cultivation or plowing, which was observed to be quite detrimental to the health and life of the trees. The general attack by bark-rot and pink diseases, pests, and plant parasites, had rendered the trees less productive. Any advantages that might have been derived from permanent cover cropping are more manifest during the second period than during the first. The advantages of cover-cropping that might be mentioned are: (*a*) increase of organic matter or humus in the soil; (*b*) prevention of erosion; (*c*) probably an increase in the nitrogen content of the soil; (*d*) perhaps a favorable condition for biological growth in the soil, due to shading and the presence of humus; and (*e*) the increase of soil moisture, preventing nefarious wilting of trees during warm days and drought. Besides, the application of fertilizer, which was started in 1929 helped to increase the average production in later years. Although all these factors may have contributed to an increase in the average production, it is believed that the extent of their effect, though not measured, would not invalidate the value of the results obtained.

The last, but not the least, points of importance to be considered in studying the relative efficiency of the orchards are the different groups of factors which determine the productivity of a tree. At least three groups of factors should be recognized, namely: (*a*) The cultural practices which are under the control of the grower; (*b*) the orchard environment and its relation to cultural practices; and (*c*) those which have to do with the inherent character of the trees themselves. Thus, according to Hodgson(7), the best results are obtained when an optimum combination of these groups is maintained. He also believes that environmental conditions as related to cultural practices, which cause most of the wide variation in yields, can be controlled at least partially, and he, therefore, suggests that these factors should be given due attention so as to improve the productivity of the orchards.

DISCUSSION OF RESULTS

Examination of data presented in the tables will show that the yields of individual trees vary from year to year; and so then does the total and average production of bearing trees in different orchards (Table 5). That a large number of trees are more or less consistently low producers, is very evident in Orchards A and B and in scattered trees. It appears that low-producing trees are generally in groups or zones in the orchards instead of being uniformly scattered over the whole orchards, a fact which indicates that orchard environment, rather than inherent quality, is in a large measure responsible for the low productivity of most trees. Unless the effects of these unfavorable environmental factors are corrected by proper orchard practices, many of the inherently productive trees, which because of adverse conditions have poor performance records, must remain poor yielders.

There is a general belief among citrus fruit growers that the death of a tree is preceded by a very heavy crop. Whenever a tree is heavily loaded with fruits the usual prediction is that its death will ensue in the following dry season. Station records of the death of 104 trees from 1924 to 1933, inclusive, show that only 11 trees produced a more or less heavy crop in the year preceding their death, indicating that only slightly more than once in ten cases is the above presumption borne out.

Table 1 shows that in 1929 a bumper crop was produced. With a favorable climate for citrus fruit production in that year, and an abnormally small crop in 1929, such a large crop as that in 1929 may be expected. The second best crop was produced in 1931 after a rather lean crop in 1930. Table 5 shows that in general alternate year production is usual with the Batangas mandarin unless unfavorable weather interferes with the crops in successive years, as in 1932 and 1933.

RELATIVE EFFICIENCY OF DIFFERENT ORCHARDS

In connection with the relative efficiency of orchards the following important points are to be considered: (*a*) percentages of bearing and nonbearing trees; (*b*) average production of bearing trees and of all trees; and (*c*) percentages of unprofitable, self-supporting, and profitable trees.

(*a*) *Percentages of bearing and nonbearing trees.*—A mandarin orchard with trees grown from seedlings, not budded,

which shows at least 80 per cent bearing trees, may be considered normal with respect to this character. For budded trees of bearing age a standard 15 per cent higher than for seedling trees may be required. Table 5 shows that the percentages of bearing trees in different orchards vary from year to year; and as the percentage of bearing trees increases there is also an increase in the average production, which shows that up to a certain limit there is a close relationship between these two characters. It is also evident that during the first five years less trees were fruiting in proportion to the total number than during the second period of five years. In this connection the first five years may be designated as an abnormal period and the second five years as a normal period.

During the first five years, or abnormal period, the average percentage of trees that fruited was 48.08 per cent in Orchard A, 47.5 per cent in Orchard B, 45.96 per cent in Orchard K, and 29.38 per cent of the scattered trees. During the normal period, Orchard A showed 89.6 per cent, B gave 82.34 per cent, K showed 91.84 per cent, whereas the scattered trees gave only 79.89 per cent. Taking all orchards and scattered trees together the bearing trees composed 43.69 per cent during the first period as compared with 84.12 per cent during the normal period. For ten years the average percentage of bearing trees was 68.84 in Orchard A, 65.12 per cent in Orchard B, 68.9 per cent in Orchard K, and 54.64 per cent in scattered trees, a general average of 63.91 per cent. During the abnormal period only Orchard A gave 82.80 per cent, in 1927, which is above the normal mark of 80 per cent. Orchard K showed the highest, and the scattered trees the lowest, percentage of bearing trees during the normal period; but none of the orchards showed a normal average percentage of bearing trees for the whole 10 years.

(*b*) *Average production of bearing trees and of all trees*—With the Batangas mandarin at bearing age an average yield of 100 fruits or less per tree is indeed a poor crop, as the income that may be derived from it is not sufficient to cover the production costs. Yields ranging from 101 to 250 may be considered hardly fair crops, inasmuch as the value of the produce will barely cover the cost of production. Any yields larger than 250 fruits per tree, considering the current price of mandarin fruits, would give a margin of profit to the grower, hence such yields may be considered good crops.

In the arbitrary classification of crops it will be noted that Orchard A produced good crops in 1929 and 1931, fair crops in 1927, 1930, and 1932, and poor crops in the other five years. The average production for the first period was very poor—only 48.88 fruits for bearing trees and 30.78 fruits for all trees. The average yield for the second period was 221.83 fruits for bearing trees and 202.60 fruits for all trees; both averages are fair or almost good.

Orchard B gave good crops in 1929 and 1931, fair crops in 1926, 1930, and 1932, and poor crops in the other five years. The average yields during the abnormal period were 63.37 fruits for bearing trees and 36.68 fruits for all trees; whereas in the normal period the averages were 193.49 fruits for bearing trees and 168.43 fruits for all trees. For ten years the average production was 128.43 fruits for bearing trees and 102.56 fruits for all trees. Orchard B gave a higher average production in the first period, but a lower one than Orchard A in the second period.

Orchard K gave good crops in 1927, and 1931, fair crops in 1924 and 1930, an almost fair crop in 1924 and poor crops in the other four years. In the first period the average production was 157.1 fruits for bearing trees, and 99.75 fruits for all trees; in the second or normal period the averages were 549.56 fruits for bearing trees and 533.13 fruits for all trees. The average production for ten years was 353.33 fruits for bearing trees and 316.44 fruits for all trees. These data show that Orchard K was almost self-supporting during the abnormal period and indeed was profitable during the normal period. Even considering the produce for the whole ten years that orchard has given a good crop on the average.

The scattered trees gave only fair crops in 1929 and 1930, an almost fair crop in 1931, and poor crops in the other seven years. The average production was 39.77 fruits for bearing trees and 11.82 fruits for all trees during the first period. In the second period, however, the averages were 134.21 fruits for bearing trees and 105.45 fruits for all trees. The averages for ten years were poor, being 86.99 for bearing trees and 58.63 fruits for all trees.

Taking together all trees in different orchards the averages during the first period were 71.19 fruits for bearing trees and 37.34 fruits for all trees, and during the second period the averages were 228.10 fruits for bearing trees and 198.54 fruits for all trees, while the averages for ten years were 179.65 fruits

for bearing trees and 117.94 fruits for all trees. The above data indicate that Orchards A and B and the scattered trees produced poor average yields, but Orchard K gave a fair or an almost fair average crop during the first five years. In the second period, however, orchard K showed good average yields, and Orchard A almost good, and the others only fair average yields. The average production for ten years was only fair for Orchard A and B, good for Orchard K, and poor for scattered trees. All trees, in the orchards and scattered trees taken together, gave a poor average production during the abnormal period and a fair or an almost good average yield during the normal or second period, but the ten-year averages were hardly fair, even counting the bearing trees only.

(*c*) *Percentages of unprofitable, self-supporting, and profitable trees.*—In accord with the preceding classification of yields it may be stated that the trees producing poor average yields may be classified as unprofitable trees or "boarders," those producing fair crops may be classified as "self-supporting" trees; and the ones giving good crops may be classified as "profitable" trees. It is evident that the value of any orchard depends upon the relative proportion of these three classes of trees. Hence, the trees were grouped into different classes according to their individual production. Only those trees which survived the test were included in this classification, however.

Table 2 shows that the highest total individual tree production, about 6,500 fruits, was obtained in Orchard K; the highest in orchard B was about 5,000 fruits; in Orchard A the highest was about 4,500 fruits; and the highest of the scattered trees was about 3,000 fruits.

The 81 living trees in Orchard A are divided into three classes: 55.56 per cent unprofitable trees or "boarders;" 32.1 per cent self-supporting trees; and only 12.34 per cent profitable trees. In Orchard B, 220 trees are classified as 65.46 boarders, 28.63 per cent self-supporters, and 5.91 per cent profit-returners. The 39 trees in Orchard K are classified as 15.39 per cent boarders, 33.33 per cent self-supporting and 51.28 per cent profitable trees; and out of 98 scattered trees 80.61 per cent are boarders, 17.35 per cent self-supporters, and only 2.04 per cent profitable. Taking all living trees into consideration, there are 438 trees, grouped as: boarders, 62.56 per cent; self-supporters, 27.17 per cent; and 10.27 per cent profitable trees.

The above data show that Orchard K, with 39 living trees, has the highest percentage of profitable trees. Because of the small number of trees in this orchard compared with other groups, its percentages cannot be given too much weight in comparison. Except for Orchard K, it may be stated that none of the groups showed higher than 13 per cent profitable trees. In fact with all trees taken together there are out of 438 trees only 45, or 10.27 per cent, that may be classified as profitable.

SELECTION OF HIGH-YIELDING TREES

In the preceding discussion the trees have been classified as unprofitable and profitable. It is very well understood that some trees that are classified as unprofitable may be inherently high yielders, unproductive because of some unrecognized unfavorable peculiarity of the individual environment. At present there is no practical way by which they can be singled out from the inherently low-yielding trees. On the other hand, not all trees having high total yields are inherently productive; they produce good crops, and are grouped with the profitable trees, because of favorable factors other than genetic. The best and surest method of selecting productive trees of highest order, in the genetic sense, is of course, by testing their clonal lines under more or less uniform field or orchard conditions. The orchards under study are indeed far from being uniform, as their description has shown.

For the present, in order to select even approximately the best of these high-yielding trees, one should determine those trees that are consistently high yielders, i. e., those tending to produce good crops from year to year. In this connection the method of approach suggested is a comparison based on the ratio between individual yields and the average yearly production of bearing trees in their respective orchards or groups.

The relative yield ratio and the average yield ratio of individual trees selected from the different groups as shown with their individual production in Table 3, are presented in Table 4. To narrow the field, only 31 of the 45 profitable trees have been included in this comparative study; and tree No. A99, which died in 1931, is added. This particular tree is survived by some of its clonal progeny which were propagated prior to its death. The average yield ratios in table 4 are also shown in Table 5, which also presents the average production of individual trees systematically arranged from the lowest to highest. The fourth

column of Table 5 shows the number of years in which the individual yields exceeded the average production of bearing trees.

The ten-year average production of the highest yielding trees, selected for comparative study, ranges from 258.2 fruits to 625.5 fruits, whereas the average yield ratio varies from 0.93 to 4.59. From these two series of data it can be realized that the average yield ratio runs more or less independently of the average production. In other words, trees having high average yields are not necessarily high in their average yield ratio.

The number of years of above-average yield, column 4, Table 5, varies from three to eight. It appears from the data presented that out of the 32 trees under study, 12 trees yielded in excess of the average production of bearing trees in their respective group in five of the ten years; 10 trees in less than five years; and the other 10 trees in more than 5 years.

SELECTED BATANGAS MANDARIN TREES

On the basis of the data presented in Table 9, it may be stated that the trees that are consistently high producers should not only show a high average yield and a relatively high average yield ratio, but also that the annual yield should be higher than the yearly average production of bearing trees in their respective orchard for more than five in ten years.

Selection 1.—Tree No. B132 is easily the best and the most consistent high yielder. It has an average production for ten years of 426.2 fruits and an average yield ratio of 4.59, and for eight of the ten years its individual yields are higher than the yearly average production of bearing trees in Orchard B.

Selection 2.—The next best tree is K23 which gave an average yield of 625.5 fruits for ten years, an average yield ratio of 2.54, and its yearly yields for seven of the ten years are higher than the corresponding yearly average production.

Selection 3.—Tree K34 is the third best tree with an average production of 469.6 fruits for ten years and an average yield ratio of 2.44. Its yields are in excess of the average yearly production for seven of the ten years.

Selection 4 to 12, inclusive.—Other good trees that are more or less consistent yielders are K4, K31, B135, B158, A13, B152, A15, A11, and S24. With more rigid selection, using 300 fruits as the minimum tolerable average production, only eight trees would be selected, eliminating the last four of those enumerated

above. It must be noted, however, that, with the exception of A13 and B135, all the selected trees have their annual yields exceeding the yearly average production in more than five years. The reason for including these two trees is that Tree A13 is the highest both in average production and in average yield ratio in Orchard A; and Tree B135 outyielded Tree B132, Selection No. 1, and is second to it in average yield ratio.

SUMMARY AND CONCLUSION

The first five-year period was characterized by low average percentage of bearing trees and low average production, as compared with the second five-year period. During the first period Orchard A showed an average of 48.08 per cent bearing trees; Orchard B, 47.5 per cent; Orchard K, 45.96 per cent; and the scattered trees, 29.38 per cent. In the seccond five-year period, Orchard A had 89.6 per cent bearing trees; Orchard B, 82.34 per cent; Orchard K, 91.84 per cent; and scattered trees 79.89 per cent. All trees taken together showed an average of 43.69 per cent bearing trees in the first period and 84.12 per cent in the second period.

The average production of bearing trees in the first period was 48.88 fruits in Orchard A; 63.37 fruits in Orchard B; 157.10 fruits in Orchard K; and 39.77 fruits for scattered trees; as compared with averages in the second period, of 221.83 fruits in A; 193.49 fruits in B; 549.56 fruits in K; and 134.21 fruits for scattered trees. All bearing trees taken together, the average production was 71.19 fruits in the first period and 228.10 fruits in the second period. These data, notwithstanding the possible effect of climatic variations, seem to indicate that the use of fertilizers, in combination with cover cropping, has increased the production of Batangas mandarins very materially. However, it is not yet well proven that their use in these orchards has been profitable.

The profitable trees constitute 12.34 per cent in A; 5.91 per cent in B; 51.28 per cent in K; and 2.04 per cent of scattered trees. Out of the total of 438 living trees, only 45 trees, or 10.27 per cent, were profitable. Orcahrd K is the most productive orchard, and Orchard A is a poor second in productivity.

The fact, that a large majority of the trees are operated at a loss, has been emphasized. Orchard environment, rather than genetic factors, are in most cases responsible for the low productivity, and it is suggested that special attention be given the

poor yielding trees, the productivity of these orchards as a whole is to be improved.

A method of comparison based on the average yield ratio is also suggested. Based on this method it is indicated that a superior tree is characterized not only by high average yield and high average yield ratio, but also by annual yields consistently exceeding the average production of bearing trees in the same orchards.

Out of 45 profitable trees there have been selected twelve that are considered consistent yielders; B132, K23, and K34 are the three best trees.

BIBLIOGRAPHY

1. WESTER, P. J. Citriculture in the Philippines. Bur. of Agr. Bull. 27 (1913), pp. 1–71.
2. MENDIOLA, N. B. A Manual of plant breeding for the Tropics. Bur. of Printing, Manila (1926), pp. 283–294.
3. FROST, H. B. Polyembryony, heterozygosis and chimeras in citrus. Hilgardia 1 (1926), pp. 365–402.
4. DE LEON, JOSE. Citrus growing in the Philippines. Philippine Journal of Agriculture 1 (1930), pp. 165–194.
5. DE CANDOLLE, ALPHONSE. Origin of cultivated plants. New York and London. D. Appleton and Company. (1919) p. 188.
6. TANAKA, TYOZABURO. Taxonomic aspect of tropical citriculture. Philip. Agrl. Rev. 19 (1926), pp. 179–184.
7. HODGSON, ROBERT W. Analyzing the citrus orchard by means of simple tree records. Univ. of Calif. Agr. Expt. Station Cir. 266 (1923), pp. 1–20.
8. TORRES, JUAN P. Progress report on citrus hybridization. Philippine Journal of Agriculture 3 (1932), pp. 217–229.

TABLE 1.—*Number and percentages of bearing and non-bearing trees and average productions of orchards, A, B, and K and scattered trees, from 1924 to 1933 inclusive*

ORCHARD A

Year	Total	Number of trees		Percentage		Total production	Average production of bearing trees	Average production of all trees
		Bearing	Non-bearing	Bearing	Non-bearing			
				Per cent	*Per cent*			
1924	95	27	68	28.42	71.58	734	27.18	7.72
1925	94	23	71	24.47	75.53	544	23.65	5.78
1926	94	57	37	60.64	39.36	3,109	54.54	33.07
1927	93	77	16	82.80	17.20	9,158	118.93	98.47
1928	93	41	52	44.09	55.91	825	20.12	8.87
1929	92	86	6	93.48	6.52	33,805	393.08	367.44
1930	91	82	9	90.11	9.89	9,397	114.09	103.26
1931	90	87	3	96.67	3.33	29,536	339.49	328.17
1932	88	77	11	87.50	12.50	7,143	96.27	81.17
1933	81	65	16	80.20	19.75	10,771	165.71	132.98
1924–28 average	93.8	45.0	48.8	48.08	51.92	2,874	48.88	30.78
1929–33 average	88.4	79.4	9.0	89.60	10.40	18,130.4	221.83	202.60
Average for 10 years	91.1	62.2	28.9	68.84	31.16	10,502.2	135.36	116.69

ORCHARD B

Year	Total	Bearing	Non-bearing	Bearing	Non-bearing	Total production	Average production of bearing trees	Average production of all trees
1924	279	128	151	46.07	53.93	7,285	56.91	26.10
1925	278	97	180	34.89	65.11	1,723	17.76	6.19
1926	278	186	92	66.81	33.09	31,683	170.33	113.96
1927	278	149	129	53.60	46.40	9,405	63.12	33.83
1928	278	106	17	38.13	61.87	924	8.71	3.32
1929	275	256	19	93.09	6.91	100,294	391.77	364.70

TABLE 1.—*Number and percentages of bearing and non-bearing trees and average productions of orchards, A, B, and K and scattered trees, from 1924 to 1933 inclusive*—Continued

Year	Total	Number of trees: Bearing	Number of trees: Non-bearing	Percentage: Bearing	Percentage: Non-bearing	Total production	Average production of bearing trees	Average production of all trees
				Per cent	*Per cent*			
1930	266	236	30	88.76	11.24	28,420	120.42	106.84
1931	245	207	38	84.49	15.51	55,665	268.91	227.20
1932	229	183	46	79.92	20.08	27,155	148.38	118.58
1933	220	144	76	65.46	34.54	5,465	37.95	24.84
1924–28 average	278.2	133.2		47.50	52.08	10,204.0	63.37	36.68
1929–33 average	247.0	205.2	145.0	82.34	17.65	43,399.8	193.49	168.43
Average for 10 years	262.6	169.2	93.4	65.12	34.87	26,801.9	128.43	102.56
ORCHARD K								
1924	57	32	25	56.14	43.86	5,267	164.59	92.40
1925	57	17	40	29.82	70.18	296	17.41	5.19
1926	57	28	29	49.12	50.88	2,709	96.75	47.52
1927	57	40	17	70.18	29.82	20,104	502.60	352.63
1928	57	14	43	24.56	75.44	58	4.14	1.01
1929	57	56	1	98.25	1.75	58,756	1,049.21	1,030.80
1930	53	51	2	96.23	3.77	12,566	245.61	236.34
1931	45	44	1	97.78	2.22	57,461	1,305.90	1,276.88
1932	41	35	6	85.37	14.63	2,835	81.00	69.14
1933	39	31	8	81.58	18.42	2,047	66.03	52.48
1924–28 average	57.0	26.2	30.8	45.96	54.04	5,686.8	157.10	99.75
1929–33 average	47.0	43.4	3.8	91.84	8.16	26,725.0	549.56	533.13
Average for 10 years	52.0	34.8	17.2	68.90	31.10	16,205.9	353.33	316.44

SCATTERED TREES

1924	109	20	89	18.34	81.66	1,490	74.50	13.67
1925	108	18	90	16.67	83.33	160	8.88	1.48
1926	108	39	69	35.78	64.22	1,669	42.79	15.45
1927	107	57	50	53.27	46.73	2,229	39.10	20.33
1928	105	24	81	22.86	77.14	806	33.58	7.67
1929	104	96	8	92.31	7.39	20,236	210.79	194.57
1930	102	86	16	84.31	15.69	6,271	72.92	61.48
1931	99	62	37	62.63	37.37	13,739	221.59	138.77
1932	98	79	19	80.61	19.39	8,533	108.01	87.07
1933	98	77	20	79.59	20.41	4,445	57.72	45.35
1924–28 average	105.4	31.6	75.8	29.38	70.61	1,270.8	39.77	11.82
1929–30 average	100.2	80.0	20.0	79.89	20.11	10,644.8	134.21	105.45
Average for 10 years	103.8	55.8	47.9	54.64	45.36	5,957.8	86.99	58.63

ORCHARDS A, B, K, AND SCATTERED TREES

1924	540	207	333	38.45	61.55	14,776	71.38	27.36
1925	537	155	382	27.01	74.99	2,723	17.56	5.07
1926	537	310	227	57.73	42.27	39,170	126.35	72.94
1927	535	323	212	60.56	39.44	40,896	126.61	76.44
1928	533	185	348	34.71	65.29	2,613	14.07	4.90
1929	528	494	34	93.57	6.43	213,091	431.27	403.58
1930	512	455	57	88.89	11.11	56,614	178.07	110.57
1931	479	400	79	83.51	16.49	156,401	391.00	326.51
1932	456	374	82	82.02	17.98	45,666	122.10	100.14
1933	437	317	120	72.61	27.39	22,728	71.69	52.01
1924–28 average	536.4	236.0	300.4	43.69	56.31	20,035.6	71.19	37.34
1929–33 average	482.4	408.0	74.4	84.12	15.88	98,900.0	228.10	198.54
Average for 10 years	509.4	322.0	187.4	63.91	36.09	59,467.8	179.65	117.94

TABLE 2.—*Distribution of old living Batangas mandarin trees in different orchards as to yields and percentages of unprofitable, self-supporting, and profitable trees.*

Classification	Orchard A		Orchard B		Orchard K		Scattered trees		Total	
(Total 10-year production)	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*
Trees producing zero to 500	19	23.46	87	39.55	2	5.13	56	57.14	164	37.44
Trees producing 501 to 1,000	26	32.10	57	25.87	4	10.26	23	23.47	110	25.11
Trees producing 1,001 to 1,500	14	17.28	39	17.73	4	10.26	16	16.33	73	16.67
Trees producing 1,501 to 2,000	9	11.11	19	8.63	4	10.26	1	1.02	33	7.53
Trees producing 2,001 to 2,500	3	3.71	5	2.27	5	12.82	0		13	2.97
Trees producing 2,501 to 3,000	9	11.11	7	3.18	5	12.82	2	2.04	23	5.25
Trees producing 3,001 to 3,500	0	0	3	1.36	2	5.13			5	1.14
Trees producing 3,501 to 4,000	0	0	1	.45	4	10.26			5	1.14
Trees producing 4,001 to 4,500	1	1.23	1	.45	5	12.82			7	1.60
Trees producing 4,501 to 5,000			1	.45	1	2.56			2	.46
Trees producing 5,001 to 5,500					1	2.56			1	.23
Trees producing 5,501 to 6,000					0				0	
Trees producing 6,001 to 6,500					2	5.13			2	.46
Number and percentages of unprofitable trees	45	55.56	144	65.46	6	15.39	79	80.61	274	62.56
Number and percentages of self-supporting trees	26	32.10	63	28.63	13	33.33	17	17.35	119	27.17
Number and percentages of profitable trees	10	12.34	13	5.91	20	51.28	2	2.04	45	10.27
Totals	81	100.00	220	100.00	39	100.00	98	100.00	438	100.00

TABLE 3.—*Production of productive old Batangas mandarin trees in orchards A, B, K, and scattered trees.*

Tree No.	Yearly production in number of fruits										Total
	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	
A 7	3	8	50	66	5	1,156	205	325	185	910	2,913
A 8	—	1	7	87	9	1,214	290	85	80	1,128	2,901
A 11	38	2	200	39	17	1,060	192	800	76	230	2,654
A 12	1	11	150	104	—	1,011	30	1,100	—	250	2,657
A 13	10	4	250	238	2	1,081	10	1,200	4	1,250	4,049
A 14	—	—	15	12	2	1,005	50	800	17	920	2,821
A 15	56	4	150	575	4	688	40	850	15	415	2,797
A 23	—	13	120	318	1	1,080	5	620	19	450	2,626
A 24	—	—	100	557	—	932	25	870	60	65	2,609
A 99	39	5	10	407	1	1,100	43	2,350	dead	—	4,055
B 114	17	94	71	439	2	358	675	750	110	66	2,582
B 132	338	78	36	1,255	—	922	557	590	330	156	4,262
B 135	9	217	1,834	15	7	922	1,076	200	537	19	4,836
B 152	310	—	40	249	9	841	278	570	64	325	2,686
B 157	—	21	675	402	—	1,100	60	120	663	—	3,041
B 158	—	12	1,026	554	2	855	210	850	301	21	3,824
B 213	22	1	1,614	—	4	1,250	180	300	30	6	3,407
B 283	5	2	491	45	25	389	975	70	800	—	2,802
B 304	45	8	250	60	43	1,488	347	950	81	26	3,298
K 2	—	3	451	408	—	1,930	497	850	195	—	4,334
K 3	13	—	5	676	—	1,314	275	1,150	21	15	3,469
K 4	127	5	1	624	2	2,258	55	2,615	150	241	6,078
K 5	288	—	1	725	—	1,977	125	1,200	85	55	4,376
K 22	79	1	14	916	5	1,678	139	1,250	25	—	4,107
K 23	265	—	550	864	—	1,793	286	2,300	54	143	6,255
K 31	104	3	20	1,357	6	1,667	297	1,515	23	68	5,060
K 34	25	42	250	985	—	1,354	413	1,450	165	12	4,696

TABLE 3.—*Production of productive old Batangas mandarin trees in orchards A, B, K, and scattered trees*—Continued.

Tree No.	Yearly production in number of fruits										Total
	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	
K 35	6	25	34	1,035	------	1,468	142	1,750	4	8	4,472
K 36	------	------	------	129	------	1,528	446	1,475	19	91	3,688
K 37	------	------	------	17	------	1,592	408	1,500	46	31	3,594
S 24	2	29	1	30	233	1,150	114	950	42	335	2,886
S 31	33	2	48	11	13	1,273	246	825	------	210	2,661

TABLE 4.—*Ratio between individual yields and the average yields of bearing trees in their respective orchards.*

Tree No.	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	Average
A 7	0.11	0.34	0.92	0.55	0.25	2.94	1.79	0.96	1.92	5.49	1.53
A 8	------	0.04	0.13	0.73	0.45	3.09	2.53	0.25	0.83	6.81	1.49
A 11	1.39	0.08	3.66	0.33	0.84	2.70	1.68	2.36	0.79	1.39	1.52
A 12	0.04	0.47	2.75	0.87	------	2.57	0.26	3.24	------	1.51	1.17
A 13	0.37	0.17	4.58	2.00	0.10	2.75	0.09	3.53	0.04	7.54	2.12
A 14	------	------	0.27	0.10	0.10	2.56	0.44	2.36	0.18	5.55	1.16
A 15	2.06	0.17	2.75	4.83	0.18	1.75	0.35	2.51	0.16	2.50	1.73
A 23	------	0.55	2.20	2.67	0.05	2.75	0.04	1.83	0.20	5.41	1.57
A 24	------	------	1.83	4.68	------	2.37	0.21	2.56	0.62	0.39	1.27
A 99	1.43	0.21	0.18	3.42	0.05	2.80	0.38	6.92	------	------	1.54
B 114	0.30	5.29	0.42	6.95	0.23	0.91	5.61	2.79	0.74	1.74	2.50
B 132	5.94	4.39	0.21	19.88	------	2.53	4.63	2.19	2.22	4.11	4.59
B 135	0.16	12.22	10.77	0.24	0.80	2.35	8.94	0.74	3.62	0.50	4.03
B 152	5.45	------	0.23	3.94	1.03	2.15	2.31	2.12	0.43	8.56	2.62
B 157	------	1.18	3.96	6.37	------	2.81	0.50	0.45	4.47	------	1.97

B 158	--------	0.68	6.02	8.78	0.23	2.18	1.74	3.16	2.03	0.55	2.54
B 213	0.39	0.06	9.48	--------	0.46	3.19	1.49	1.12	0.20	0.16	1.66
B 283	0.09	0.11	2.88	0.71	2.87	0.99	8.10	0.26	5.39	--------	2.14
B 304	0.79	0.45	1.47	0.95	4.94	3.80	2.88	3.53	0.55	0.69	2.00
K 2	--------	0.17	4.22	0.81	--------	1.84	2.02	2.78	2.17	--------	1.40
K 3	0.08	--------	7.08	1.34	--------	1.25	1.12	3.75	0.23	0.23	1.51
K 4	0.77	0.29	6.55	1.24	0.05	2.15	0.32	8.54	1.67	3.65	2.51
K 5	1.75	--------	7.49	1.44	--------	1.88	0.51	3.92	0.94	0.83	1.88
K 22	0.48	0.06	9.47	1.82	0.12	1.60	0.57	4.08	0.28	--------	1.85
K 23	1.61	--------	8.94	1.72	--------	1.70	1.16	7.51	0.60	2.17	2.54
K 31	0.64	0.17	14.02	2.70	0.14	1.59	1.21	4.95	0.26	1.03	2.67
K 34	0.15	2.41	10.18	1.96	--------	1.29	1.68	4.73	1.83	0.18	2.44
K 35	0.04	1.44	10.70	2.06	--------	1.40	0.58	5.71	0.04	0.12	2.21
K 36	--------	--------	1.33	0.26	--------	1.46	1.82	4.82	0.21	1.38	1.13
K 37	--------	--------	0.81	0.03	--------	1.52	1.66	4.90	0.51	0.47	0.93
S 24	0.03	3.27	0.02	0.77	6.94	5.45	1.58	4.29	0.39	5.80	2.85
S 31	0.44	0.23	1.12	0.28	0.39	6.04	3.41	3.72	--------	3.64	1.93

TABLE 5.—*Showing the average yields and average yield ratio of productive mandarin trees in orchards A, B, K, and scattered trees in Tanauan Citrus Station.*

Tree No.	Average production	Average yield ratio	Number years yield average	Remarks
B 114	258.2	2.50	5	
A 24	260.9	1.27	4	
A 23	262.6	5.57	5	
A 11	265.4	1.52	6	Selection 11.
A 12	265.7	1.17	4	
S 31	266.1	1.93	5	
B 152	268.6	2.62	7	Selection 9.
A 15	279.7	1.73	6	Selection 10.
B 283	280.2	2.14	4	
A 14	282.1	1.16	3	
S 24	288.6	2.85	6	Selection 12.
A 8	290.1	1.49	3	
A 7	291.3	1.53	4	
B 157	304.1	1.97	5	
B 304	329.8	2.01	5	
B 213	340.7	1.66	4	
K 3	346.9	1.51	5	
K 37	359.4	0.93	3	
K 36	368.8	1.13	5	
B 158	382.4	2.54	6	Selection 7.
A 13	404.9	2.12	5	Selection 8.
A 99	405.5	1.54	4	
K 22	410.7	1.85	4	
B 132	426.2	4.59	8	Selection 1.
K 2	433.4	1.40	5	
K 5	437.6	1.88	5	
K 35	447.2	2.21	5	
K 34	469.6	2.44	7	Selection 3.
B 135	483.6	4.03	5	Selection 6.
K 31	506.0	2.67	6	Selection 5.
K 4	607.8	2.51	6	Selection 4.
K 23	625.5	2.54	7	Selection 2.

A NEW DISEASE OF COTTON (*GOSSYPIUM* SP.) IN THE PHILIPPINES

By Feliciano M. Clara
Of the Bureau of Plant Industry

THREE PLATES

The possibilities of cotton growing in the Philippines in their various aspects have been the subject of no small number of treatises. However, the diseases of this plant appear to have received very little attention. Many of the recorded diseases in other countries are not known in the Philippines, but they could readily be introduced here with the introduction of seeds from foreign countries and local sources. This is especially the case when seeds are of doubtful origin and when they are produced without considering the factor of disease-freedom. Plants grown from such seeds offer a good means of detecting and intercepting disease transmitted in this manner. The cotton project of the Bureau of Plant Industry consisting of over forty varieties, hybrids and strains at the Central Experiment Station offered an opportunity for a study of this nature. With the exception of the varieties Batangas, "Kapas purao" and Keute, all of the other varieties, such as the Sakha, Ashmuoni, Sea Island and so on, which have been used as parent plants for breednig were imported from foreign countries

Periodical observations for the presence of diseases have been conducted since 1932. Within a short time angular leaf spot (*Phytomonas malvaceara, Bacterium solanacearum* Erw. Smith) reported by Reinking (1918), Anthracnose (*Glomerella gossypii* Edg.) and (*Colletotrichum gossypii*) reported by Welless (1921, 1922) were encountered. With these diseases other important ones not previously reported from the Philippines appeared on some of the plantings particularly on the varieties Sea Island and Ferguson. These diseases are commonly known as *Helminthosporium* blight, *Cercospora* leaf spot (*Cercospora althaeiana* Sacc.) club leaf (cyrtosis) and another leaf disease associated with *Alternaria sp.*

This brief report deals with the results of a study on the *Helminthosporium* blight. Recommendations on the control of important diseases of cotton transmitted by seeds are also included.

NATURE OF THE DISEASE

The leaves, bract and bolls are the most conspicuous parts of the plant attacked by the disease. On the plantings of the station the early symptoms were noted when the plants were 4 to 6

inches tall. On the leaves spots of various sizes and shapes are observed (Plate 1, fig. 1). They may be circular, zonated and sometimes irregular brown lesions on the margin of the leaves. The lower leaves show more of the disease, either due to the more favorable condition above the ground or due to the sources of infections and the conditions of the leaves. Which of these factors or combination of factors is mainly responsible for this seemingly more susceptible condition of the lower leaves was not determined. The spots may attain considerable sizes and very irregular shapes especially when two or more of them coalesce forming bigger spots. In the advance stage of the disease, the spots on the leaves may break off in a shot hole fashion. On the same diseased leaves other fungi belonging to the genera *Alternaria*, *Gloeosporium* and *Cercospora* are sometimes observed, but the *Helminthosporium* appears to be more abundant, especially at an early stage of the occurrence of the disease (Plate 1, fig. 2). In nature some of the lesions on the leaves may show distinct zonation concentrically formed (Plate 3, fig. *c*). On the bolls, spots of various sizes are observed (Plate 2). The badly diseased leaves are sometimes entirely involved and fall on the ground. The infected plants may show an impairment of their normal development as shown by the size of the plants and the time of flowering compared with varieties with little or no disease at all. The badly infected plants are stunted.

IMPORTANCE AND DISTRIBUTION OF THE DISEASE

Tucker (1926) first observed and reported this disease of cotton from Porto Rico, on Sea Island cotton plants. Later, the same disease was reported from the cotton growing region in the southern part of America. How it was introduced into the Philippines could not be ascertained. It is very probable, however, that it may have originated from infected pieces of plant parts introduced with imported cotton seeds.

In Porto Rico and in the cotton growing region of the Southern States of America this disease was reported as of economic importance. During the last two cotton seasons, the disease was studied and observed in the Central Experiment Station, Bureau of Plant Industry, Manila, as causing noticeable damages. Its occurrence in 1933 was more severe than in 1934 season. The plantings for these two years were not conducted on the same location, but the lot of the second year's plantings was closely adjacent to that of the previous year. No attempt at determining the causes of the variations in the virulence of the disease was made.

Fortunately the disease has not as yet been reported from other cotton growing regions of the Philippines. It appears very likely that its presence in the Central Experiment Station may have come with the newly introduced cotton seeds from foreign countries.

THE PATHOGEN

Pathogenicity.—A fungus associated with the diseased parts was isolated and cultured on a number of media. The organism reproduced the disease on cotton plants grown in pots and inoculated with bits of hyphae of the fungus. The inoculated plants were placed in a moist chamber, with a temperature of 20–30 ° C. for 48 hours. During the rest of the observations, the plants were kept in the greenhouse (green house with glass roof and wire mesh as walls). The results of the first series of inoculations are shown in Table 1.

TABLE 1.—*Showing the results of the first series of artificial inoculation on Ferguson var.*

Date	No.	Treatments	Observation after—		
			3 days	40 days	48 days
1933					
May 28	1	Inoculated with spore suspension	—	+	Small brown spot.
	2	do	—	+	Do.
	3	do	—	+	Do.
	4	do	—	—	—
	5	do	—	—	—
	6	do	—	+	Small brown spot.
	7	do	—	—	—
	8	do	—	+	Small brown spot.
	9	do	—	+	Do.
	10	do	—	+	Do.
	11	do	—	—	—
	12	do	—	—	—
	13	do	—	+	Small brown spot.
	14	do	—	—	—
	15	do	—	+	Small brown spot.
	16	do	—	+	+
	17	do	—	—	—
	18	do	—	+	Small brown spot.
	19	do	—	+	+
	20	do	—	+	+
	21	Control	—	—	—
	22	do	—	—	—
	23	do	—	—	—
	24	do	—	—	—
	25	do	—	—	—
	26	do	—	—	—
	27	do	—	—	—

Infections on the inoculated points with profuse growth of the fungus were observed in two days. The lesions were circular brownish but lacking the concentric ring observed on lesions found under natural conditions.

In the second series of infection studies, inoculations on leaves of all stages from the youngest to the lowest ripe leaves and on bolls, also of different ages, were conducted. All cultures used for inoculations were grown on potato dextrose agar. The results of these inoculations are shown in Table 2.

TABLE 2.—*Inoculation with Helminthosporium on leaves and bolls of cotton (Ferguson var.)* *

Date	No.	Condition of leaves at time of inoculation	May 31	June— 2	4	5	
May 29	1	8 injuries. Young pods	—	—	—	—	
	2	8 injuries. Maturing pods	—	—	—	—	
	3	8 injuries. Matured pods	+	+	+	100%	Suture opening.
	4	8 injuries. Matured pods. Sign of drying.	+	+	+	+100%	
	5	8 injuries. Matured pods	+	+	+	+100%	
	6	8 injuries. Matured	—	—	—	—	Control.
	7	8 injuries. Matured	—	—	—	—	Control.
ON LEAVES OF ALL STAGES FROM THE YOUNGEST TO THE OLDEST							
	9	10 points. Upper surface. Youngest open leaf.	—	—	—	—	
	10	10 points on upper and lower surface. Next young leaf down.	—	—	—	—	
	11	10 points upper surface. Next or third leaf down.	+?	+	+	+	
	12	10 points upper surface. Next or fourth leaf down.	+?	+	+	+	
	13	10 points lower surface. 10 points on edges of young leaf.	—	—	—?	—?	
	14	10 points lower surface on a young leaf.	—	—	—	—	

* A plus (+) sign means that infection has been obtained; a minus (—) sign indicates that no infection was obtained.

It may be noted that the matured leaves readily showed infections while the youngest leaves did not. This same manifestation was observed on the inoculations on bolls (Plate 2). The infections on the bolls at first appeared as circular spots slightly sunken, and dark brown but later assumed irregular shapes of

various sizes. The inoculations made near the suture showed a breaking up of the shell, eventually exposing the lint (Plate 2).

GROWTH ON MEDIA

The growth of the fungus was observed on potato dextrose agar, corn meal, potato plug and oat meal.

Potato dextrose.—Greyish to black growth is produced on this medium. Abundant aërial growth with many spores is observed in ten days.

Steamed corn meal.—The growth on this medium is very active, no less abundant than on potato dextrose agar. Aërial growth and spores are readily produced. Dark mycelial growth becomes more marked with age.

Steamed oat meal.—A very active growth similar to the growth on potato dextrose agar and steamed corn meal is produced. Spores are produced within 10 days.

MORPHOLOGY

The mycelium is colorless when young. Some of the mycelia from old cultures show dark brown color under the microscope.

Conidia.—The conidia vary in shape from clavate, curved or elliptic, to straight. The base shows the broadest diameter tapering upward to the apex (Plate 3, figs. *b, d, e*). They are colorless under the microscope. Measurements of the spores show a range of dimensions: 77–164.5 by 12–16 μ average size 115 x 13.3 μ. The number of septations observed range from 5 to 18. Fifty per cent of them are 6–9 septate.

Conidiophores.—The conidiophores are olive brown, single or in groups, 2 to 4 septate; dimensions ranging from 20–44 x 1.8–2.0 μ with an average measurement of 30.2 x 5.9 μ.

Comparison of Philippine *Helminthosporium* with the Porto Rico *Helminthosporium* as described by Tucker.

Philippine Helminthosporium	*Porto Rico Helminthosporium*
CONIDIA	
Extremes of meas: 77–164.65 x 12–6μ	Extremes of meas: 35–118 x 11.7–18.4μ
Average dimension: 115 x 14.3μ	Average dimension: 87 x 15.3μ
Class 70–115μ width 55 per cent	Class 70–115μ width 85 per cent
Class 13–17μ width 50 per cent	Class 13–17μ width 95 per cent
Range of septation = 5–18 50 per cent with 6–9 septation.	Range of septation = 1–8 85 per cent with 4–7 septation.

CONIDIOPHORES

Extremes of meas: 81–162.8 x 5.5–7.4μ	Extremes of meas: 40–185 x 6.5–8μ.
2–4 septation	1–5 septate
Single or in group olive brown. Variable in shape: straight, cylindrical to nodose or bent.	Single or in group of three brown variable, from straight, cylindrical to nodose or bent.

The morphological characters of the fungus when compared with those of *Helminthosporium gossypii* described by Tucker (1926) in Porto Rico showed some differences in the size of conidia and conidiophores. The conidia of the Philippine *Helminthosporium* gave extreme measurements ranging from 77–164.65 by 12–16μ while Tucker's organism gave a range from 35–118 by 11.7–18.4μ. The average dimension of the Philippine fungus is 115 by 14.3μ and the Porto Rican *Helmonthosporium* is 87 by 15.3μ. However, the majority of the measurements of conidia fall in the same class range with the *Helminthosporium gossypii* reported by Tucker. More septations are observed with Philippine *Helminthosporium* but the majority fall in the same class.

The dimensions of the conidiophores were also very variable. Those of the Philippine fungus gave extremes from 81–162.8 by 5.5–7.4μ, while the conidiophore measurements of the Porto Rican fungus is 40–185 by 6.5–8μ. The septations showed only a slight difference.

In physiological characters the two organisms are very similar. Considering the variability of the morphological characters of this organism and the close similarity of the two organisms in a number of important characters, the Philippine organism is referred to *Helminthosporium gossypii* Tucker.

CONTROL MEASURES

The following recommendations are known to be effective in the control of the important diseases of cotton carried by seeds:

1. Clean seeds free from particles that usually come with careless handling should be used for planting. Seeds for planting should be obtained from cotton bolls and plants with no symptoms of diseases.

2. Some of the diseases like anthracnoses are known to be starved out by storing the seeds in dry places for one to two years.

3. The bacterial blight or black arm (*Phytomonas malvaceara*) is controlled by hot water treatment of the seeds. This practice should be employed wherever practicable, but especially when the history of the origin of the seeds is not known, or of doubtful sources.

4. In any case the seeds should be delinted with concentrated sulfuric acid and then treated in hot water at 72° C. for 18 minutes (follow carefully the direction given by Walker (1930) to avoid mistakes and achieve the desired results.

5. A periodical inspection of the plantings to detect early infections should be conducted. Such practice accompanied by removal of infected plants or leaves may help in checking the diseases.

6. All introduced seeds should be grown in an isolated place for observation of diseases.

SUMMARY

1. A disease on cotton not before known to be present in the Philippines was found on introduced seeds of cotton.

2. The cause of the disease and its virulence as it occurred on the different varieties, hybrids and strains of cotton was observed.

3. The disease is caused by a fungus referred to as *Helminthosporium gossypii* Tucker.

4. Selection of seeds from disease-free plants, careful handling of the seeds and seed disinfection will greatly help in checking the disease.

LITERATURE CITED

REINKING, OTTO A.: Philippine economic plant diseases. Philippine Journal of Science 13: 208–209. (1918.)

WELLES, C. G.: Two serious plant diseases new to the Philippines. Philippine Agriculturist 10: 253–254. (1921.)

———— A provisional list of parasitic fungi of the Philippine Islands. Phil. Agric. Rev. 15: 203. (1922.)

ELLIOT, JOHN A.: Cotton wilt a seed borne disease. Jour. Agric. Res. 23: 387. (1923.)

TUCKER, CLARENCE MITCHEL: A leaf, bract, and boll spot of Sea Islands cotton caused by Helminthosporium gossypii. Tucker. Jour. Agric. Res. 32: 391–397. (1926.)

WALKER, M. N.: Cotton diseases in Florida. Univ. of Florida Agric. Expt. Sta. Bull. 214: 1–30. (1930.)

ILLUSTRATIONS

PLATE 1

FIG. 1. Leaf showing the lesions infected with *Helminthosporium gossypii.* 7/10 of natural size.

2. A leaf of cotton (Ferguson variety) inoculated with *Helminthosporium gossypii.* Infections indicated by 1, 2, 3, 4, and 5. 7/10 of natural size.

PLATE 2

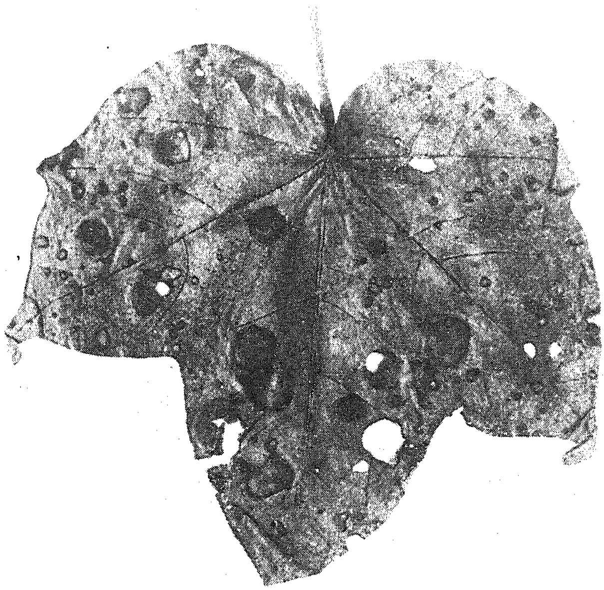
FIG. 1. Cotton bolls (Batangas variety); right shows lesions (1, 2, 3, 4, and 5) due to natural infection with *Helminthosporium gossypii.* Collected from cotton plants grown in Silang, Cavite. April 27, 1934. 8/10 of natural size.

2. Cotton bolls (Ferguson variety) inoculated with *Helminthosporium gossypii* June, 1934. Fruit on the extreme left was used as check showing non-infected artificial punctures. 7/10 of natural size.

PLATE 3

a. Leaf infected with *Helminhosporium gossypii* showing the lesions in one of the specimens collected at the Central Experiment Station, Manila, December 20, 1932. 2/5 of natural size.

b to *j.* Conidia and conidiophores of *Helminthosporium gossypii* from the lesions of the infected leaf. ×412.



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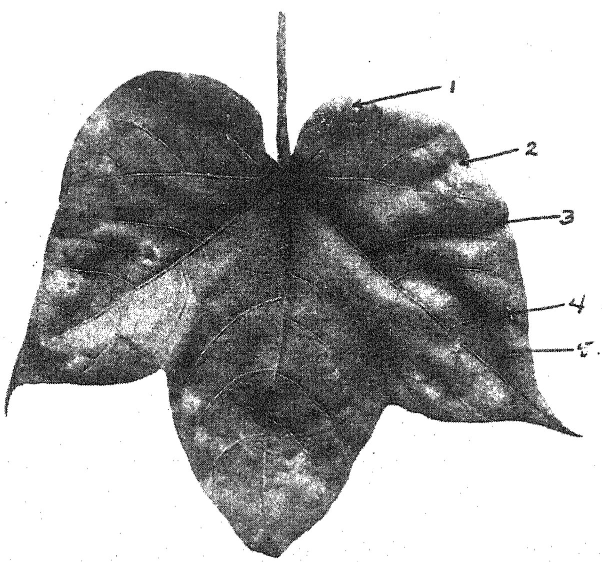

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PLATE 1.

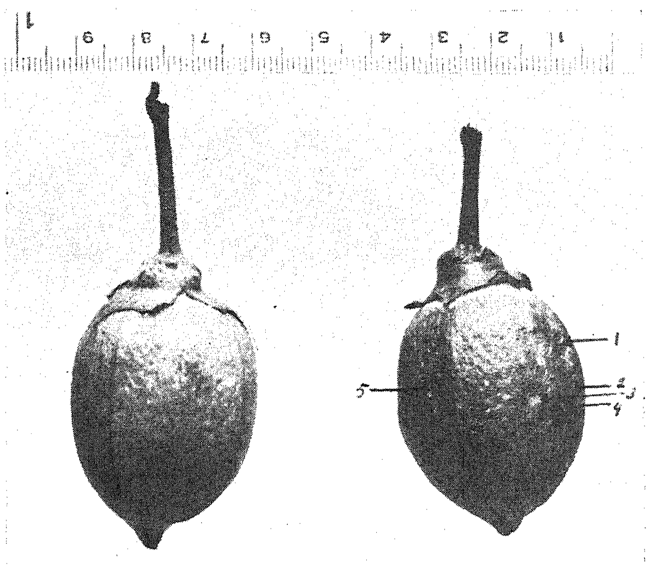

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PLATE 2.

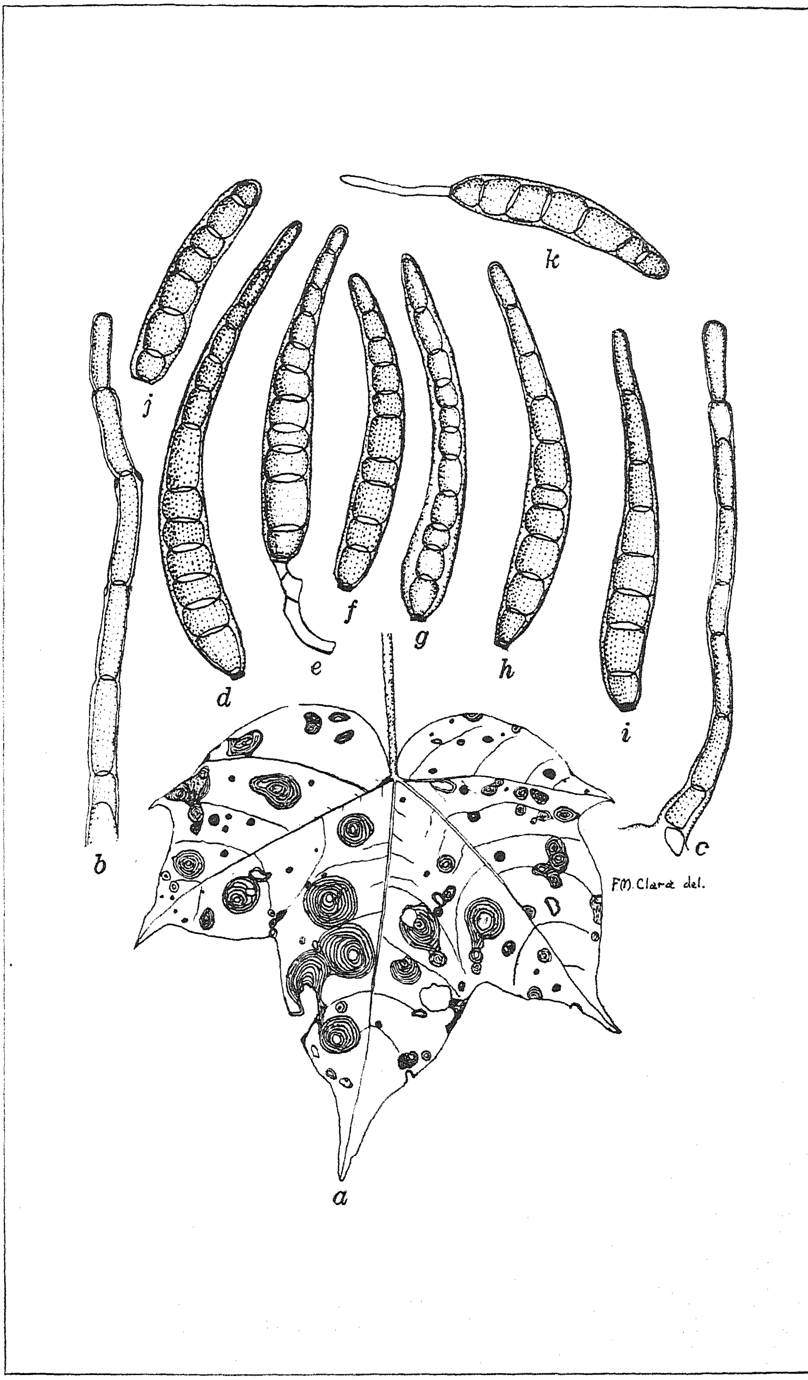

PLATE 3.

AGRICULTURAL ABSTRACTS

NITROGEN FIXATION STUDIES WITH FUNGI AND ACTINOMYCES

By FRANKLIN E. ALLISON, senior chemist; Sam R. Hoover, assistant scientific aid; and Herman J. Morris, assistant scientific aid; Biological and Organic Division, Fertilizer Investigations, Bureau of Chemistry and Soils, United States Department of Agriculture.

Experiments made with nine cultures of true fungi, including 8 strains of *Aspergillus* and 1 *Cladosporium* and with five species of common soil actinomyces, grown in various media, showed no nitrogen fixation.

"A critical consideration of all of the evidence on the subject indicated strongly that nitrogen fixation is, at most, limited to a very few species of the free-living fungi, and the data for these are certainly not conclusive. The evidence that certain mycorrhizal fungi can use atmospheric nitrogen, at least when growing in the roots of the host, is much stronger. (Adapted from the Journal of Agricultural Research, Vol. 49, No. 12, pp. 1115–1123, December 15, 1934.)

A STUDY OF THE COTTON ROOT-ROT FUNGUS (PHYMATOTRICHUM OMNIVORUM) IN THE SOIL BY THE CHOLODNY METHOD.

By E. D. EATON, junior pathologist; and C. J. KING, agronomist; Division of Cotton and Other Fiber Crops and Diseases. Bureau of Plant Industry, United States Department of Agriculture.

By the Cholodny technic which "consists in exposing standard microslides in the soil under field conditions" it has been observed that:

"(1) *Phymatotrichum mycelium* was active in the soil at least 6 weeks before the first symptoms were observed on nearby cotton plants.

"(2) The growth of the mycelium in the soil apparently was not connected with roots; and

"(3) The mycelium developed in a clean fallow."

The writer further suggested that the Cholodny technic may be used for:

(1) Biological and control studies.

(2) As a means of ascertaining the presence of fungus in fallow lands, and

(3) In studies of its interrelations with other organisms. (Adapted from the Journal of Agricultural Research, Vol. 49, No. 12, pp. 1109–1113, December 15, 1934.)

SOME MICROBIOLOGICAL ACTIVITIES AFFECTED IN MANURIAL CONTROL OF COTTON ROOT-ROT

By C. J. KING, agronomist; CLAUDE HOPE, junior horticulturist; and E. D. EATON, junior pathologist; Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Division of Agriculture.

An experiment conducted at the United States Field Station, Sacaton, Arizona, since 1921, demonstrated the effectiveness of organic manures applied in deep furrows in controlling the cotton root-rot disease, *Phymatotrichum omnivorum* in irrigated lands. The following theories were advanced in explanation of the above results:

(1) The organic acids from the decomposing manure reduce the alkalinity of the soil and make it less favorable for the fungus;

(2) The evolution of ammonia in the manured plots inhibits or kills the fungus;

(3) The stimulation received by the fertilized plants gives them greater resistance;

(4) Many roots are caused to develop superficially and are thus able to escape the fungus attack;

(5) The manure increases the number and activities of competitive organisms which inhibit the growth and development of the root-rot fungus.

An investigation was made in 1933 to verify the fifth explanation above-mentioned. Comparisons of microbiological activities in 4 quarter-acre plots which had received applications of manure for several years with that of 5 alternate plots of the same size which received no manure, was made.

Comparisons between adjacent plots showed that the manured plots had 19 to 152 per cent greater evolution of CO_2 than the unmanured plots, indicating an activity of soil micro-organisms

in the decomposition of an increased content of organic materials.

It was also found, by the Cholodny method of direct microscopic examination, that bacteria and actinomycetes in various forms and most fungi were more abundant on the slides exposed in the manured plots. The root-rot fungus, *Phymatotrichum omnivorum*, was more abundant on the slides exposed in the unmanured plots.

The tests further showed that the population of many organisms is greatly increased by large applications of organic matter to the soil and that the dense populations or organisms engaged in breaking down the organic materials developed a soil condition temporarily unfavorable for the growth and activity of the root-rot fungus, causing a rapid and prolonged reduction of root-rot activity. (Adapted from the Journal of Agricultural Research, Vol. 49, No. 12, pp. 1093–1107, Dec. 15, 1934.)

TRANSMISSIBILITY BY APHIDS OF THE TOBACCO MOSAIC VIRUS FROM DIFFERENT HOSTS

The writer has previously presented evidence that aphids do not transmit the tobacco mosaic virus from tobacco to tobacco and other writers have also shown that extensive attacks may be adequately accounted for on the basis of other modes of infection and spread.

"In repeated tests of the ability of three species of aphids in large numbers to transmit the ordinary tobacco mosaic virus from various solanaceous and other hosts, transmission was obtained with regularity only from tomato (*Lycopersicum esculentum* and *L. pimpinellifolium*).

"In general, the greatest amount of transmission of the tobacco mosaic virus from any host was effected by *Myzus pseudosolani*; less infestation was obtained with *Macrosiphum solanifolii* and least with *Myzus persicae*.

"By transferring known numbers of aphids from tobacco-mosaic-diseased *Lycopersicum pimpinellifolium* to plants of the hybrid *Nicotiana tabacum* x *N. glutinosa* and counting the number of local lesions of tobacco mosaic produced, it was estimated that, with *Myzus pseudosolani*, about 1 aphid in 129 caused infection; with *Macrosiphum solanifolii* about 1 aphid in 140; and with *Myzus persicae* about 1 aphid in 800 or more. Comparative tests indicated that, in the transmission of a crucifer mosaic

virus by *M. persicae* to tobacco, 1 aphid in 4 or 5 acted as vector, and, in transmission of the sugar beet mosaic virus to tobacco by the same aphid, approximately 1 aphid in 4.

"It is concluded that the more common aphids probably do not transmit the ordinary tobacco mosaic virus from certain hosts, and only rarely or with great difficulty from other hosts. It not only seems unlikely that any appreciable amount of dissemination of tobacco mosaic may be brought about by aphids, except perhaps from tomato, but it is even doubtful whether much of the sporadic infection occurring on tobacco may be accounted for in this way." (Adapted from Hoggan, Iomi A. Transmissibility by Aphids of the Tobacco Mosaic Virus from Different Hosts. Journal of Agricultural Research, Vol. 49, No. 12, pp. 1135–1142, Dec. 15, 1934.)

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FLOWER BEHAVIOR OF AVOCADO VARIETIES

By FRANCISCO G. GALANG and EMILIO K. MORADA

Of the Horticulture Section, Bureau of Plant Industry

THREE TEXT FIGURES

The avocado is said to have been introduced into the Philippines from Mexico as early as 1890. However, its successful introduction dates back only about twenty-nine years ago from Hawaii, Costa Rica and the United States. The growing of the avocado is a promising commercial venture in the Islands. Its fruit is finding a ready sale in the market and fetches a better price than that of other fruits because of its high fat-food value. There are now avocado trees growing in widely separated localities in the Philippines and the behavior of these trees clearly indicates that the plant is at home in this country. It was only lately, however, that the avocado has been planted on a more or less commercial scale.

It has been reported that the avocado varieties now growing in the Islands fruit indifferently. Opinion seems to be unanimous that many avocado varieties fail to bear fruit satisfactorily owing to a lack of pollination brought about by the failure of the flower to open at the proper time, or to incompatibility of the pollen itself. In the Philippines no study has so far been reported as regards the flower behavior of the avocado or its failure to bear fruit from this point of view. But Nirody(1), Stout(2), Robinson and Savage(3), Van Elden(4), and Ryerson(5) have obtained results showing that even though the avocado flowers profusely under favorable soil and climatic con-

ditions and with proper cultural treatment, it may fail to produce fruits or, in the event of setting, the fruits may drop off prematurely due to the fact that its flowers tend to open in unison. Each flower opens and closes for two distinct periods at different times during its cycle; one set is receptive while the other is shedding its pollen. During the first opening the pistil is almost always receptive but no pollen is shed, and during the second opening the pollen is shed but by this time the pistil is usually past the receptive stage. Self-incompatibility exists in some avocado varieties and in a few varieties a considerable overlapping between the two periods of opening occurs, thus making possible a very limited self-pollination. Such overlapping is sometimes affected by weather conditions. As pointed out by Stout(2), variable weather conditions, particularly abrupt changes in illumination, temperature, humidity and wind exposure, cause marked changes in the rather precise periodicity of flower opening during clear, warm, bright weather. These changes result in the increase of the amount and prolongation of overlapping, frequently increasing the opportunity for self-pollination many fold. The fruiting of isolated trees in some localities and occasionally by solid-blocks of well-known varieties might be due to this according to Ryerson(5). Thus the more satisfactory setting of fruits of some varieties where atmospheric conditions are subject to both continual and frequent sudden changes is partially explained in all probability by this increased overlapping. For this reason, the interplanting of avocado varieties having flowers opening at different times has been recommended so as to produce the best result. In the Philippines the avocado has been and is still being planted without taking into consideration its flower behavior so that now we find many handsome and vigorously growing trees that either fail to bear fruit or if they do, only very sparingly.

Stout(2), Robinson and Savage(3), and Ryerson(5) believe that fruit setting in avocado will be more successful if compatible varieties are interplanted whose flowers open at such time that will permit cross-pollination, or if self-compatible varieties are discovered, the opening periods of whose flowers overlap. According to these authors, until we find self-compatible varieties, the mixed planting of two or more varieties of avocado has necessarily to be followed in laying out an orchard of this tree in order to obtain the best possible results. Stout and Robin-

son and Savage have grouped the avocado varieties into two; namely, Group A and Group B, each group shedding pollen at different times. The avocado orchard planning, therefore, as recommended by these authors should include varieties of both the A and the B group, each shedding pollen at such a time as to coincide with open flowers in a receptive mode on the other reciprocating variety. Furthermore, the varieties to be chosen should have approximately the same or at least an overlapping flowering season; early bloomers of the A group, for example, are unsuited for planting with distinctly late bloomers of the B group. The midseason bloomers would serve both for planting with early or late varieties, since the flowering season of the avocado usually lasts several weeks. The lack of compatibility between varieties may still interpose difficulties, but the mixed planting at least immeasurably increases the chances for effective pollination, as compared with solid planting of one variety or of varieties all having the same periodicity of bloom. It is for this reason that the present observations of the flowering habits of the avocado varieties at the Lamao Horticultural Station, Lamao, Bataan; Tanauan Citrus Experiment Station, Tanauan, Batangas; Lipa, Taal, Talisay, and Mataas-na-kahoy, Batangas; San Fernando and Mexico, Pampanga; Calumpit, Bulacan; Indang, Cavite; and in Los Baños, Laguna, have been undertaken during the 1933–34 and 1934–35 flowering seasons of the avocado.

MATERIALS AND METHODS

All the varieties either budded, grafted or seedling trees that have so far fruited at the Lamao Horticultural Station and at the Tanauan Citrus Experiment Station, and several privately owned trees in Lipa, Taal, Talisay and Mataas-na-kahoy, Batangas; San Fernando and Mexico, Pampanga; Calumpit, Bulacan; Indang, Cavite; and in Los Baños, Laguna, were observed as regards their flowering habits. The main observation was conducted in Lamao, however. In Lamao flowers of 22 trees consisting of 18 named and 4 unnamed avocado varieties were studied; in Batangas (Tanauan, Lipa, Taal, Talisay and Mataas-na-kahoy) 40 named and 151 trees of unnamed varieties; in Pampanga (San Fernando and Mexico) 12 unnamed trees; in Bulacan (Calumpit) 1 named and 2 unnamed trees; in Cavite (Indang) 1 named and 30 unnamed trees; and in Laguna (Los Baños) 2 named and 46 unnamed trees, thus making a total of

307 trees. Records of the closing and opening of from 63 to 852 avocado florets of each tree, or a total of 61,286 florets from different panicles were taken during the two flowering seasons—January to May, 1934, and November, 1934 to April, 1935. A preliminary study of the flowers was first made as a guide in determining the important parts and characters of the flowers opening during the first and second periods. Before the appearance of the flower buds or while the flowers were still in the bud stage, the general characteristics of the flower buds were compared with those of the leaf buds, originating both from the terminal and lateral twigs. The place of origin of the flower buds were also determined. In Lamao several flowering shoots whose flowers were about to open were marked and labelled. Daily observations lasting from early in the morning till late in the afternoon were taken of the opening, receptiveness of the stigma, and closing of the first period flowers on the different trees. The time of opening and closing, including the shedding of the pollen in the second opening period, were recorded together with the weather conditions. To find the cause of the setting of fruits of some isolated trees in the 1935 flowering season, the number and percentage of fresh stigmas or those appearing receptive during the latter opening period were noted. In other places the same procedure was followed but the observations of the flowers from each tree were performed only once for a day or so. This short time observation was considered accurate enough for this study since the flowers of an avocado variety behave in the same way and the flowers which opened for the first time can be easily distinguished from the flowers that opened for the second time.

To determine the number of flowers borne on each terminal as well as on the lateral shoots, a count of the individual flowers in a panicle of fifty twigs each of two varieties of avocado in Lamao was made. Descriptions of the flower buds which were about to open and those that had opened for the first time were made from trees in Lamao, Lipa, Tanauan and Mataas-na-kahoy during the 1934 flowering season. Similarly during the two flowering seasons, the extent of the defoliation accompanying the formation of flowers of the Lamao avocados was noted.

In accordance with the foregoing observations, the avocado varieties studied were grouped or classified as to the manner of defoliation, flower opening, and the corresponding graphs were drawn for the opening of the flowers.

DISCUSSION OF RESULTS

The flower and the leaf buds of the avocado varieties in Lamao began to appear as early as August, while the flower panicles from these flower buds developed during the dry season—from November to May—or when the trees were in their dormant condition. An overgrown stock plant (unnamed variety) of avocado flowered the earliest and the Cyrus the latest. In the 1933–34 flowering season, it took 64 days for the flower buds of the Family variety to develop fully into panicles and 147 days for the Cyrus and Pollock; while in the 1934–35 flowering season 21 days for the Commodore and 83 days for the Tumin. The length of time it takes for the flower panicle to develop from its first appearance as a flower bud apparently depends much on the health of the tree and partly on the weather conditions. The time of flowering depends much upon the vigor of the trees and to the soil and climatic conditions. Table 1 gives the flowering period of the avocado varieties in Lamao.

TABLE 1.—*Showing the flowering time of the avocado varieties at Lamao, Bataan*

Variety	Budded, grafted, or seedling	1933–1934				
		Date of appearance of—			Number of days from—	
		Flower bud	Flower panicle	Last appearance of flower	Bud to panicle	Panicle to last appearance of flower
Quality	B	9- 5-33	1-11-34	3-25-34	128	73
Unnamed	S	8- 1-33	11-15-34	3- 1-34	106	106
Avocado No. 1	S	9- 9-33	1- 4-34	3- 1-34	117	56
Wester	B	10- 1-33	1-25-34	3-25-34	116	59
Family	G	12- 1-33	2- 3-34	3- 5-34	64	30
Dickinson	B	11- 5-33	2-12-34	3-30-34	99	46
Lyon	B	12-10-33	3-10-34	4-20-34	90	41
Cyrus	S	10-10-33	2-25-34	5-10-34	147	74
Cyrus	S	2-12-34	5- 3-34	6- 4-34	80	32
Cyrus	B	10- 1-33	2-20-34	4-25-34	142	64
Commodore	B	12- 1-33	3-10-34	5- 1-34	99	52
La Carlota No. 7	G	9- 1-33	1-25-34	2-29-34	147	36
Avocado No. 5	S	10- 1-33	1-15-34	2-20-34	106	36
Pollock	B	10- 1-33	2- 5-34	4-15-34	127	69
Pollock	S	10- 1-33	2-25-34	4-30-34	147	64
Tumin	B	12- 1-33	3- 8-34	4-15-34	97	38
Cardinal	B	11-10-33	3- 8-34	5-10-34	118	63
Cardinal	B	11- 5-33	1- 8-34	4-14-34	123	37
Waldin	B	12-10-33	3-10-34	4-20-34	90	41
Vega	B	9- 5-33	1-11-34	4-14-34	128	93
Cummins	B	12- 5-33	3-10-34	5-15-34	95	36

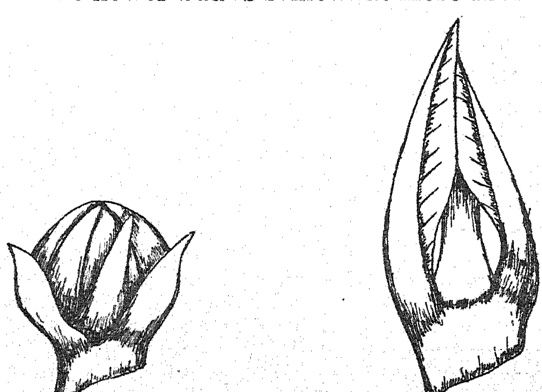
TABLE 1.—*Showing the following time, etc.*—Continued.

Variety	Budded, grafted, or seedling	1934-1935				
		Date of appearance of—			Number of days from—	
		Flower bud	Flower panicle	Last appearance of flower	Bud to panicle	Panicle to last appearance of flower
Quality	B	12-20-34	2- 3-35	3- 5-35	45	30
Unnamed	S	9-20-34	11- 3-34	1-10-35	44	68
Avocado No. 1	S	11-30-34	1-10-35	2-28-35	41	48
Wester	B	11-30-34	1- 9-35	3-25-35	40	75
Family	G	(a)	(a)	(a)	(a)	(a)
Dickinson	B	(b)	(b)	(b)	(b)	(b)
Lyon	B	12-20-34	1-20-35	3- 8-35	31	47
Cyrus	S	11-30-34	12-25-34	3-10-35	25	75
Cyrus	S	1-20-35	2-20-35	3-20-35	31	28
Cyrus	B	12-20-34	2-20-35	2-25-35	62	33
Commodore	B	1-25-35	2-15-35	3-15-35	21	28
La Carlota No. 7	G	10- 5-34	12- 8-34	1- 2-35	64	25
Avocado No. 5	S	10- 7-34	11-25-34	2-13-35	79	80
Pollock	B	10- 1-34	11-25-34	1-15-35	55	51
Pollock	S	11- 7-34	1- 2-35	3- 8-35	57	65
Tumin	B	11-25-34	2-15-35	3-12-35	83	25
Cardinal	B	1-20-35	2-23-35	3-30-35	34	35
Cardinal	B	1- 9-35	2-20-35	3-30-35	42	38
Waldin	B	(a)	(a)	(a)	(a)	(a)
Vega	B	8-28-34	10-20-34	3-10-35	53	140
Cummins	B	11-25-34	2- 2-35	----------	69	----------

[a] Did not flower in 1935 [b] Blown down by the storm in 1935

NOTE.—B stands for budded plants, S for seedlings, and G for grated plants

When the scales and transition leaves of an avocado bud develop very slowly, it indicates that the bud is going to be a flower bud. The flower bud is somewhat more rounded in shape



(*a*) Flower bud (*b*) Leaf bud

FIG. 1. Buds of Wester avocado.

than the leaf bud as shown in text fig. 1 (*a*) and measures from 3 to 5 mm. long and 2 to 4 mm. across. On the other hand, the leaf bud as shown in text fig. 1 (*b*) is pointed and the scales are normal in size and grow faster than those of the flower

FIG. 2. Flower clusters produced from the trunk of La Carlota No. 2 avocado topworked on Dickinson

buds. The avocado trees generally flower at the end or tip of the shoots or at the axil of the leaves near the tip of the previous season's growth. However, in a few instances flower panicles are developed from the big branches as in text fig. 2. The flower panicles produced at the tip of the shoots were usually more vigorous and branched more freely than those panicles

originating elsewhere on the tree. Almost all twigs of heavy bearing trees flowered.

The flowering of the avocado is generally accompanied by either heavy or light defoliation depending upon the variety and the quantity of flowers produced, and this leaf fall is immediately followed by the development of new leaves. Still other varieties flower without changing their leaves.

Trees which flowered heavily in 1934, as in the case of the Unnamed Tree, Lyon, Commodore, Cardinal, Vega and Cummins shed their leaves heavily. On the other hand, only slight defoliation occurred during the flowering season in 1935 on trees which produced but few flowers such as the Quality, Lyon, Cyrus, Commodore, Pollock, Cardinal, Vega and Cummins. The natural tendency of a bearing twig in almost all varieties of avocado is to defoliate its leaves at or previous to flowering and then superseded immediately with the development of new leaves to support the fruits. Consequently, a heavy flowering tree would defoliate heavily, and the opposite would occur on trees with few flowers.

TABLE 2.—*Showing the leaf fall of avocado varieties at Lamao, Bataan*

Variety	Budded, grafted, or seedling	Defoliation of leaves						Quantity of flowers	
		1934			1935				
		Heavy	Light	None	Heavy	Light	None	1934	1835
Quality	B	—	X	—	—	X	—	Light	Light.
Unnamed	S	X	—	—	X	—	—	Heavy	Heavy.
Avocado No. 1	S	X	—	—	—	—	X	Heavy	Very light.
Wester	B	—	X	—	—	X	—	Heavy	Heavy.
Family	G	—	—	X	—	—	—	Light	None.
Dickinson	B	—	X	—	—	—	—	Light	None.
Lyon	B	X	—	—	—	X	—	Heavy	Light.
Cyrus	B	—	—	X	—	—	X	Light	Light.
Cyrus	S	—	X	—	—	X	—	Light	Light.
Commodore	B	X	—	—	—	X	—	Heavy	Light.
La Carlota No. 7	G	X	—	—	X	—	—	Heavy	Heavy.
Avocado No. 5	S	X	—	—	X	—	—	Heavy	Heavy.
Pollock	B	X	—	—	X	—	—	Heavy	Heavy.
Pollock	S	—	X	—	—	X	—	Light	Light.
Tumin	B	X	—	—	X	—	—	Heavy	Heavy.
Cardinal	B	—	X	—	—	X	—	Light	Light.
Cardinal	B	X	—	—	—	X	—	Heavy	Light.
Waldin	B	—	X	—	—	—	—	Light	None.
Vega	B	X	—	—	—	X	—	Heavy	Light.
Cummins	B	X	—	—	—	X	—	Heavy	Light.

NOTE.—B stands for budded plants, S for seedlings, and G for grafted plants

The extent of defoliation of other varieties of avocado sometimes varies with the different trees of the same variety. For instance, a tree of the Cardinal variety defoliated heavily while another tree of the same variety defoliated lightly only; some trees of the Pollock and Cyrus varieties behaved similarly. This may be accounted for partly by the influence of the stock plant used, since the seedling trees of these varieties behaved uniformly as regards their leaf fall.

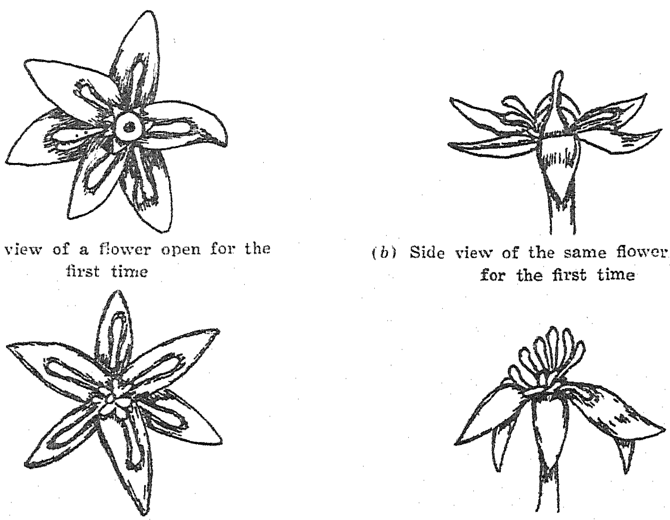
The avocado flower is small and perfect and is characterized by the entire absence of sepals and with rather scarce pollen. The stigma is small and slightly curved to pointed tip, bright greenish-canary in color, watery and sticky at the receptive stage. It varies in size depending upon the variety and vigor of the tree—9–13 mm. in diameter; petals 6–8, and from 3–7 mm. long and 2–3 mm. broad; stamens 3–4 in number in the first layer and 6–8 in the second, and 3–4 mm. long and 0.5–1 mm. wide; anther, 0.9–2 mm. long and 0.5–1.5 mm. wide; ovaries, 1–2.5 mm. long and 0.9–1.5 mm. in diameter; nectaries, 0.9–2 mm. long and 0.8–1.5 mm. wide. .

The flower bud is oval to rounded in shape and when about to open is either light apple-green, greenish-canary, or light green and when fully developed it is either canary, greenish-canary, apple-canary, or light green. (Standard Dictionary, Twentieth Century Edition, was used for the color guide.)

The count made of the total number of flowers from 100 panicles gave an average of 162.9 flowers per terminal panicle and 203.5 for the panicle produced on the lateral twigs. An over-grown stock plant had fifty of its terminal twigs bearing more flowers than the lateral twigs or 7,111 individual flowers against 4,389, while Avocado No. 1 had fifty lateral twigs bearing 15,993 individual flowers against 9,188 of the terminal. Therefore, based on the average number of flowers per twig, the former produced 142 for the terminal and 87 for the lateral twigs, while in the latter there were 183 for the terminal and 319 for the lateral twigs. However, the peduncles of the terminal twigs are more stocky and larger than those of the lateral twigs. A full-grown bearing avocado tree produces thousands upon thousands of flowers so that if out of these flowers even a fraction of one per cent will develop into fruits an abundant crop may be expected.

Behavior of the flower.—The flowers of avocado in general have two distinct periods of opening and closing during their life cycle. It took 34 hours for the flower of the Group A varie-

ties to complete its cycle (from first opening to its final closing) and only 24 hours for the Group B varieties. The period during which a flower is again closed, that is, between the first and second periods of opening is longer in the former group than in the latter or 23 against 11 hours. As the flowers are produced successively, consequently the first opening of some flowers coincides with the second opening of other flowers every day during the flowering season. On the first opening the flowers with all the stamens, nectaries and corolla are on a flat plane and the ovary with its stigma is well exposed which indicates that it is ready to receive the pollen, as shown in text fig. 3 (*a*) and (*b*). A few minutes after the first opening of the



(*a*) Top view of a flower open for the first time

(*b*) Side view of the same flower open for the first time

(*c*) Top view of a flower open for the second time

(*d*) Side view of the same flower open for the second time

FIG. 3. Various stages of flowers of Cyrus avocado

flower the stigma becomes receptive and remains in this condition until the flower closes for the first time. The same flower reopens on the following day when the pollen is shed but the stigma in most cases is no longer capable of receiving the pollen because it is already in a constricted condition and of a brownish color and sometimes has the sign of rottening at the tip. At this time the small white sacks of the anther bearing the pollen extend outside the openings of the anther on the two sides ready to discharge their contents. The stigma is in general lower than the first layer of stamens which are standing closely side by side with it so that even if it is receptive the chances of pollina-

tion by insects is rather remote. At this stage the corolla are hanging in outward direction and the first layer of stamens are standing close to the pistil while the second layer of stamens and all nectaries are in a slanting position as shown in text fig. 3 (*b*).

Avocado varieties whose flowers open for the first time in the morning will reopen in the afternoon of the following day, while varieties whose flowers open for the first time in the afternon will again open the next morning. This periodicity of flower opening is found to be a fixed character of the varieties, and thus far no proved exceptions have been found under normal weather conditions according to Robinson and Savage(3). In our study, however, we found a tree owned by Mr. P. Whitaker of San Fernando, Pampanga, the flowers of which opened only once. In the majority of cases the flowers of this particular tree opened from 7:05 to 8:10 a. m. and began closing from 11 a. m. to 9:15 p. m. Still other flowers remained open till night time. This unusual and long opening period of the flowers was not due to the variance in climatic conditions as pointed out by Stout(2) since the weather during the three days of our observations of the flowers of the tree in question was rather uniform. Furthermore, there are no findings so far reported that the sudden change of the weather, as for instance, from bright to either cloudy, shower, or rain, may omit one of the opening periods of any avocado flowers. The effects of weather on the opening and closing of avocado flowers are presented in Table 3 and the corresponding graph.

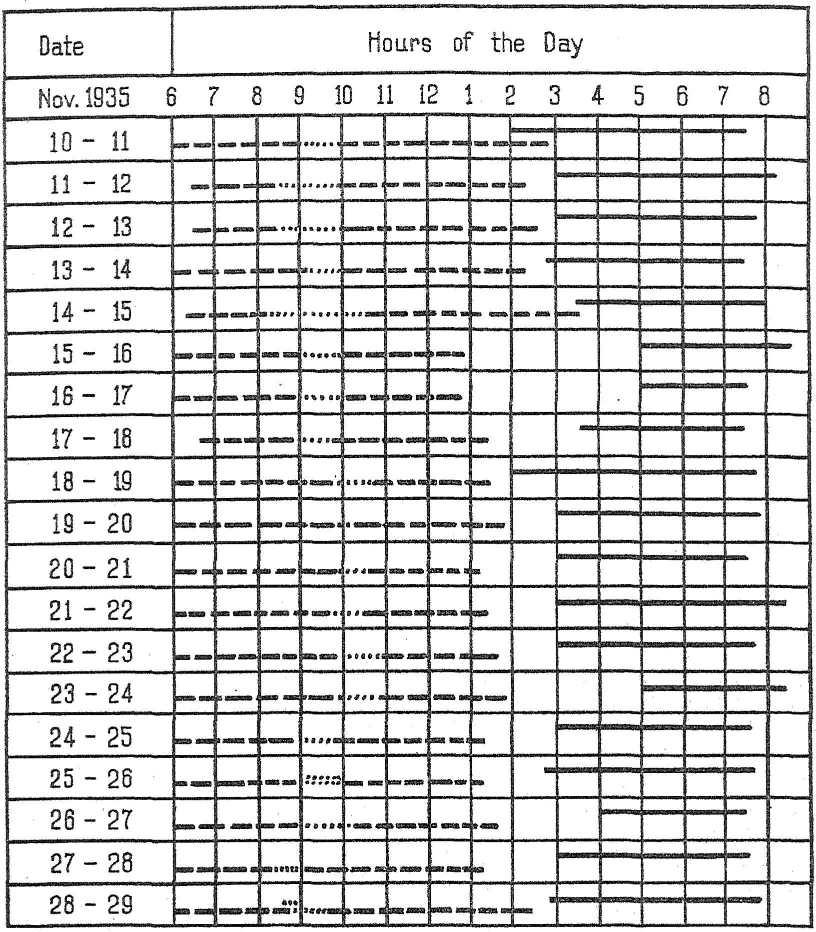
As shown in Graph I cloudiness or rain has very little influence on the time of opening and closing; it retarded a little the first opening and closing period on November 14–15 and 28–29, respectively. On the other hand, on November 10–11, 11–12, and 12–13 when the weather was bright, the opening and closing were also variable. In connection with the effect of weather, observations were also made on the behavior of the flowers under different temperatures. The results are given in Table 4.

As shown in Table 4, a higher temperature preceding the opening of the flowers hastened the time of opening as on November 17–18, 19–20, and 20–21; while a lower temperature retarded it as on November 18–19 and 21–22.

As the receptiveness of the stigma and dehiscence of pollen of the same flower of an avocado variety occur at different periods practically no pollination takes place or if at all, very

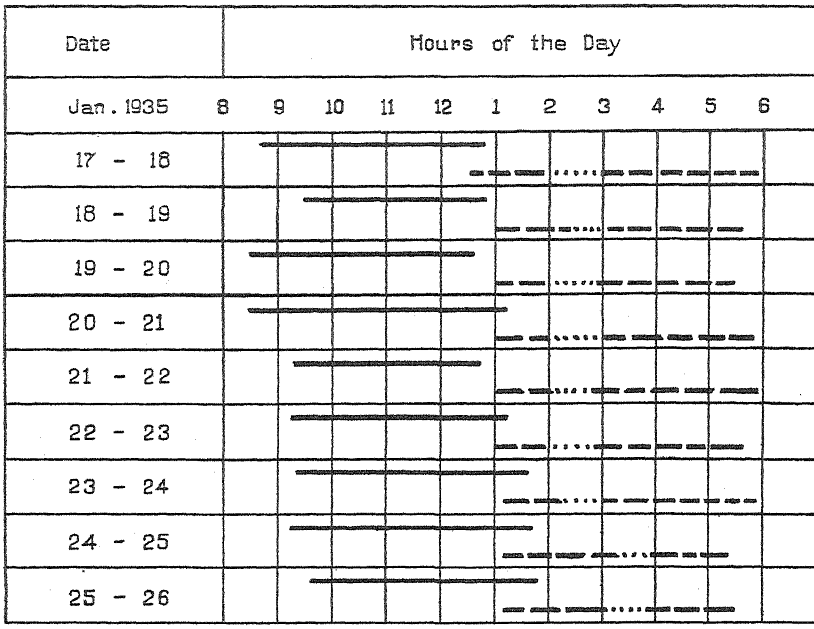
TABLE 3.—*Showing the first and second periods of opening and closing of flowers of Vega avocado as influenced by the weather conditions*

Date of observation November 1935	Number of flowers observed	First opening period p. m.			Second opening period a. m.			Weather	
		Time of—							
		Opening	Receptiveness of stigma	Closing	Opening	Pollen Dehiscence	Closing	A. M.	P. M.
10–11	66	2:00–5:15	2:05–5:20	7:00–7:45	6:00–7:59	9:15–9:50	1:00–2:55	Bright	Bright.
11–12	82	3:00–5:15	3:05–5:20	8:00–8:10	6:30–7:59	8:40–9:50	1:00–2:20	Bright	Bright.
12–13	99	3:00–4:59	3:05–5:02	7:00–7:55	6:25–7:59	8:40–9:50	12:40–2:45	Bright	Bright.
13–14	127	2:50–5:20	2:55–5:25	7:00–7:30	6:00–7:59	9:15–9:59	12:30–2:20	Partly cloudy and bright	Cloudy.
14–15	113	3:30–4:59	3:35–5:03	7:20–7:59	6:25–7:40	8:20–10:20	2:00– 3:40	Rainy and windy	Rainy and windy.
15–16	243	5:00–5:30	5:05–5:35	8:00–8:30	6:00–7:59	9:00– 9:59	12:00–12:55	Cloudy, rainy and windy	Cloudy, rainy and windy.
16–17	215	5:00–6:30	5:05–5:35	7:00–7:20	6:00–7:40	9:00– 9:59	12:00–12:55	Partly cloudy and bright	Partly bright, cloudy and rainy.
17–18	311	3:45–4:55	3:50–5:00	7:00–7:30	6:35–7:10	9:00– 9:30	11:00– 1:30	Partly cloudy and bright	Bright.
18–19	371	2:00–4:59	2:05–5:03	7:00–7:55	6:00–7:00	10:00–10:20	12:00– 1:45	Partly bright and cloudy	Bright.
19–20	137	3:00–4:30	3:05–4:35	7:00–7:50	6:00–7:30	10:00–10:05	1:00– 1:50	Bright	Bright.
20–21	192	3:00–4:20	3:05–4:25	7:00–7:35	6:00–7:15	10:00–10:15	1:00– 1:25	Bright, partly cloudy and shower.	Rainy and cloudy.
21–22	134	3:00–5:10	3:05–5:15	8:00–8:10	6:00–7:06	10:00–10:10	12:00– 1:30	Bright	Bright and partly cloudy.
22–23	127	3:00–5:25	3:05–5:30	7:00–7:40	6:00–6:40	10:00–10:45	1:00– 1:45	Cloudy and partly bright	Cloudy and rainy.
23–24	151	5:00–7:10	5:05–7:15	8·00–8:20	6:00–7:15	10:00–10:30	10:00– 1:55	Cloudy and partly bright	Cloudy and rainy.
24–25	163	3:00–4:35	3:05–4:40	7:00–7:35	6:00–6:45	9:00– 9:30	1:00– 1:25	Bright	Partly cloudy and bright.
25–26	228	2:50–4:59	2:55–5:03	7:00–7:40	6:00–6:50	9:00– 9:50	1:00– 1:25	Bright	Bright and partly cloudy
26–27	156	4:00–4:30	4:04–4:33	7:00–7:25	6:00–6:45	9:00–10:05	1:00– 1:30	Bright	Bright.
27–28	103	3:00–4:10	3:05–4:15	7:00–7:30	6·00–6:40	8:30– 8:50	1:00– 1:25	Bright	Bright and partly cloudy.
28–29	151	2:50–4:59	2:54–5:03	7:00–7:40	6:00–6:40	8:40– 9:20	1:30– 2:30	Cloudy and showering	Cloudy with shower.



GRAPH I. Showing the flower behaviors of Vega avocado as influenced by the weather conditions.

slight. Because of these intervening periods of flower opening of the avocado, only very few flowers are capable of reciprocating each other. Pollen is shed only on the second opening of the flower, at which time most of the stigmas were usually past the receptive stage. Since varietal compatibilities are seldom found to exist among the commercial varieties cultivated, the only chance of pollinating the stigma by insects—insects are the chief agents of pollinating the avocado flowers for a successful fruit production—is to have an overlapping of the receptiveness of the stigmas of some varieties during the first opening period with the period of dehiscence of pollen of other varieties. This



GRAPH II. Showing the flower behaviors of the unnamed stock for Dickson avocado as influenced by the daily temperature.

may be accomplished in three ways, viz., (1) by interplanting varieties in which the receptiveness of their stigmas coincides with the dehiscence of pollen of other varieties, provided insects and bees are present to effect pollination from trees to trees; (2) by topworking a portion of the trees with one or more reciprocating varieties in an already established orchard composing of one variety or varieties of one group provided the varieties to be topworked have approximately the same vigor and flowering period with the topworked trees; and (3) by planting avocado seedlings. This system of planting may result in the production of trees belonging to both the A and B groups thus facilitating cross-pollination. However, the planting of vegetatively grown plants is more desirable for the reason that asexually grown trees in most cases come true to type.

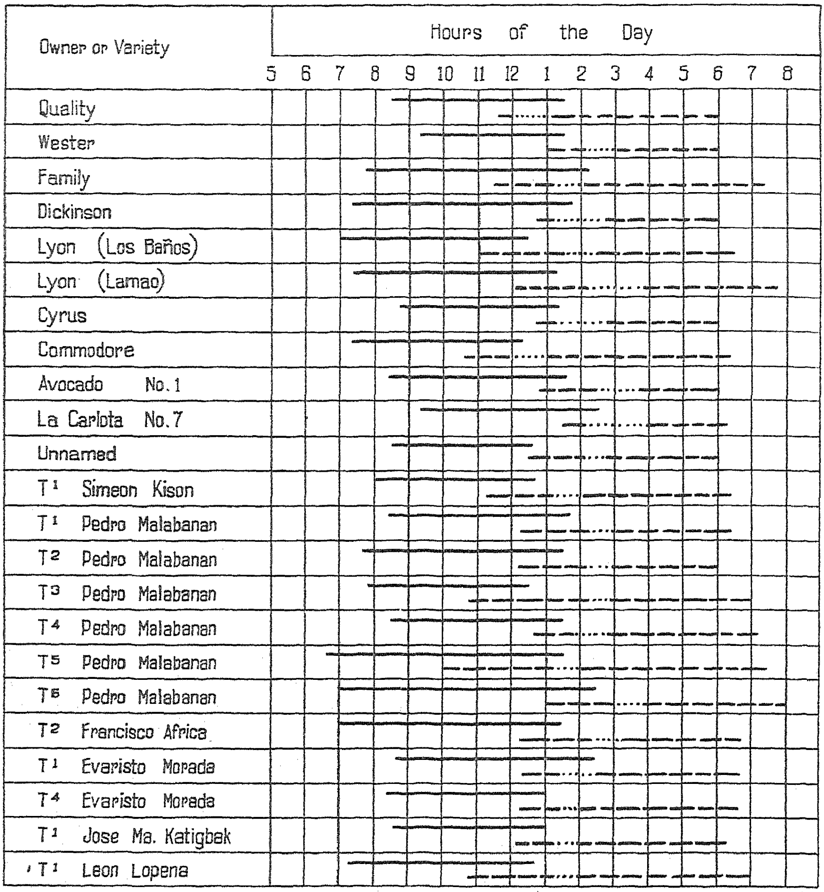
As already stated elsewhere Robinson and Savage(3) and Stout(2) have grouped the avocado varieties into two—the A and B groups. Group A are the varieties whose flowers open for the first time in the morning and dehisce their pollen in the afternoon of the following day, and Group B are the varieties whose flowers open for the first time in the afternoon and dehisce their pollen the next morning as indicated in Graphs III and IV drawn

TABLE 4.—*Showing the first and second periods of opening and closing of the flowers of an unidentified variety of avocado as influenced by temperature*

Date of observation January 1935	Number of flowers observed	First opening period A. M.		
		Time of—		
		Opening	Receptiveness of stigma	Closing
17–18	398	8:45– 9:59	8:50–10:03	12:15–12:59
18–19	290	9:25–10:30	9:30–10:35	12:00–12:59
19–20	381	8:30– 9:30	8:35– 9:35	11:35–12:40
20–21	529	8:40– 9:45	8:45– 9:50	12:00– 1:10
21–22	274	9:15– 9:30	9:20– 9:35	12:40–12:50
22–23	417	9:35–10:50	9:40–10:55	1:00– 1:25
23–24	291	9:30– 9:50	9:35– 9:55	1:15– 1:45
24–25	354	9:20– 9:50	9:25– 9:55	1:30– 1:50
25–26	279	9:40– 9:50	9:45– 9:55	1:15– 1:55

Date of observation January 1935	Number of flowers observed	Second opening period P. M.		
		Time of—		
		Opening	Pollen dehiscence	Closing
17–18	398	12:30–1:59	2:00–2:50	4:40–5:50
18–19	290	1:00–1:30	2:35–2:59	4:40–5:40
19–20	381	1:00–1:45	2:00–2:38	5:00–5:30
20–21	529	1:00–1:59	2:00–2:50	5:10–5:50
21–22	274	1:00–1:15	2:00–2:45	5:15–5:55
22–23	417	1:00–1:20	2:00–2:50	5:15–5:40
23–24	291	1:15–1:30	2:15–2:50	5:30–5:50
24–25	354	1:10–1:40	3:30–3:50	5:15–5:45
25–26	279	1:15–1:45	3:30–3:40	5:15–5:48

Date of observation January 1935	Number of flowers observed	Temperature in Centigrade					
		A. M. (8–11)			P. M. (12–5)		
		Minimum	Maximum	Average	Minimum	Maximum	Average
17–18	398	24.0	26.4	25.37	27.0	31.0	25.26
18–19	290	23.2	27.0	24.87	25.5	29.2	27.95
19–20	381	24.5	27.0	26.05	24.5	27.5	25.81
20–21	529	23.6	27.0	25.35	26.0	28.9	27.90
21–22	274	22.5	28.0	24.87	24.0	28.0	26.00
22–23	417	21.0	26.5	23.50	25.0	28.9	25.36
23–24	291	22.0	28.5	25.92	25.2	26.0	25.36
24–25	354	23.5	26.0	24.92	26.5	29.0	27.63
25–26	279	24.8	27.6	26.72	26.8	27.8	27.16

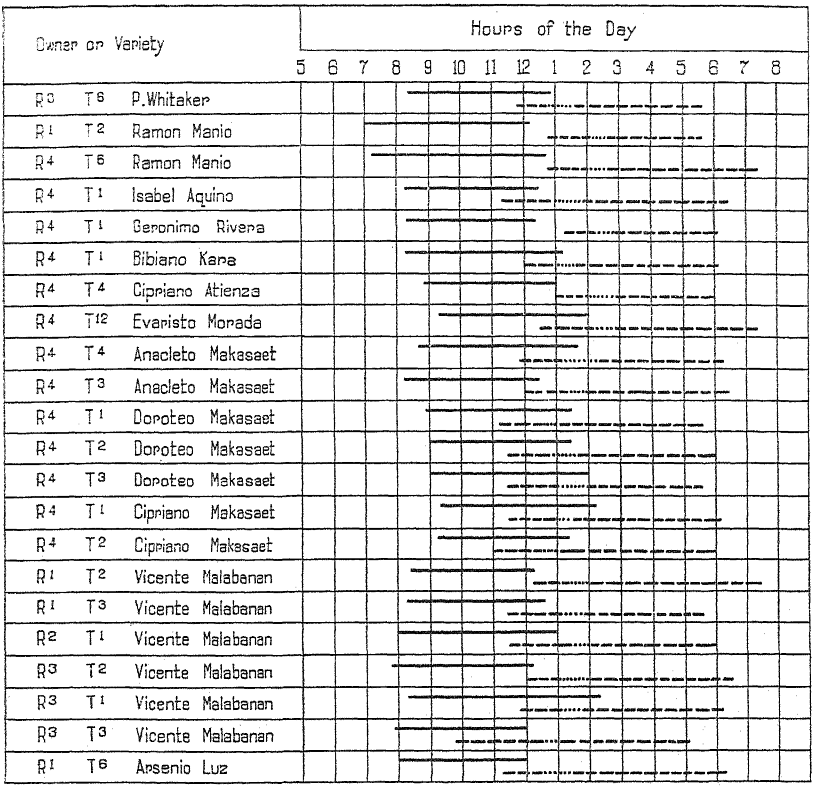


GRAPH III (*a*). Showing the flower behavior of avocado varieties under Group A.

from hourly observations which tables being too long were purposely omitted.

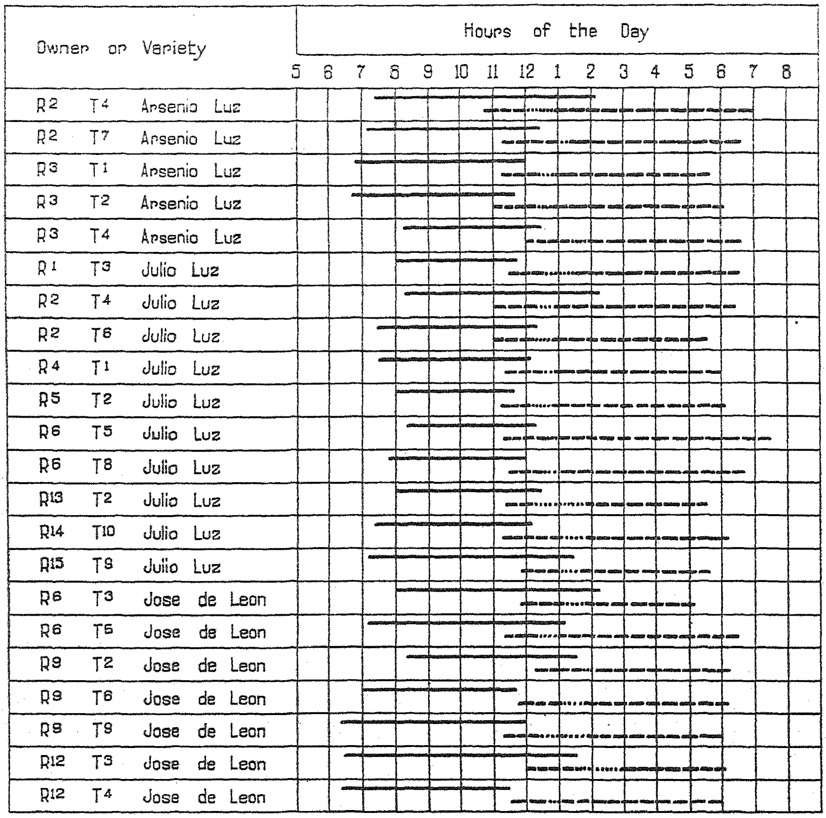
In these graphs the solid lines indicate the first opening periods of the flowers of the different varieties of avocado when the stigmas are receptive, and the second opening periods, by the broken lines while the dots between the broken lines when the pollen started to dehisce.

The time of the dehiscence of pollen and the receptiveness of the stigma varied according to the varieties. In 1934, the duration from opening to closing of the flowers of the avocado varieties under Group A in Lamao and in Batangas ranged from 2 hours and 50 minutes to 7 hours and 30 minutes for the first opening period and from 4 to 8 hours and 30 minutes for the



GRAPH III (*b*). Showing the flower behavior of avocado varieties under Group A.

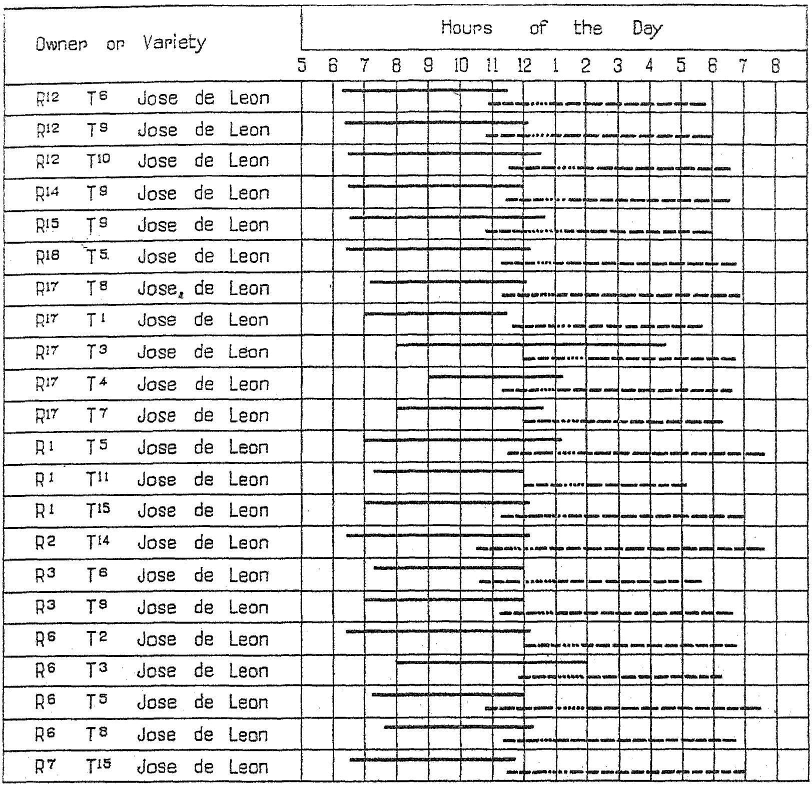
second period. In 1935, it ranged from 2 hours and 10 minutes to 6 hours and 50 minutes and from 4 hours and 30 minutes to 9 hours and 20 minutes. The stigma became receptive in 2 to 10 minutes and remained receptive until the closing of the first opening period of the flower. The dehiscence of the pollen took place from ½ to 3 hours and 50 minutes during the second opening of the flower. The interval from the first opening to the second period ranged from 20 hours and 50 minutes to 26 hours and 40 minutes, while the varieties under Group B the duration was from 1 hour and 30 minutes to 7 hours and 8 minutes for the first opening, 2 hours and 45 minutes to 14 hours and 10 minutes for the second period. The stigma is receptive in 2 to 10 minutes and the dehiscence of pollen from 35 minutes to 3 hours and 25 minutes. The interval of the first to the second opening range from 7 hours and 15 minutes to 16 hours.



GRAPH III (*c*). Showing the flower behavior of avocado varieties under Group A.

The pollen of the varieties in Groups A and B remained fresh from the time of dehiscence up to 5 and 12, respectively, and at which time most of the pollen have already been carried away by insects. At the second opening the stigmas of some of the trees in Groups A and B appeared to be still receptive, while the stigmas of other trees were no longer fresh as shown on Tables 5 and 6.

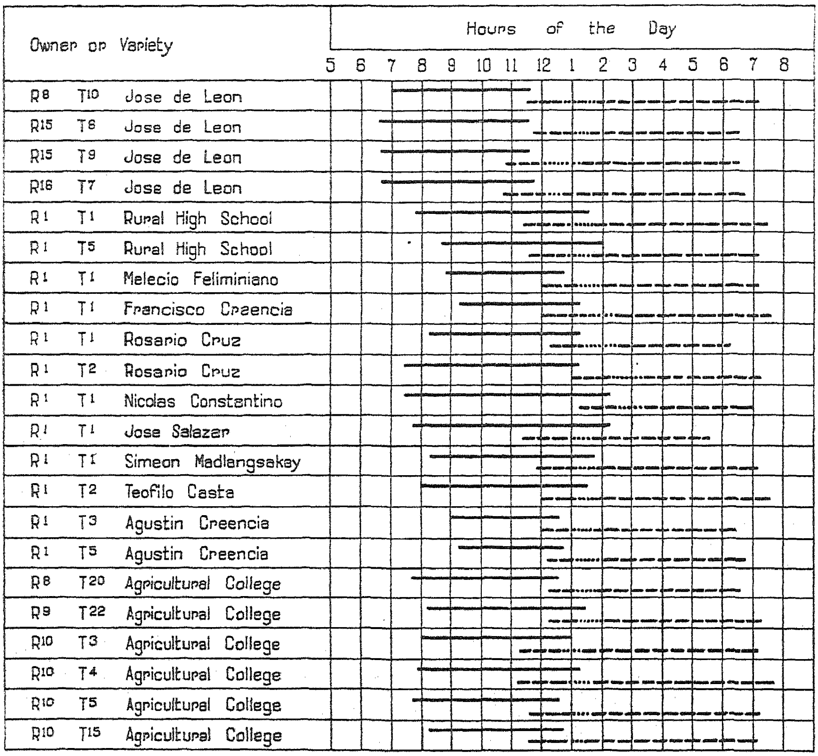
In Group B there were more trees with fresh stigmas during the second opening period of the flowers than in Group A or 78 against 50. This may be due to the fact that in Group A the flowers of the avocado suffer more from the heat of the sun than the flowers in Group B since their first opening period is in the morning, while the flowers of the avocado in Group B first open in the afternoon. The percentage of the fresh stigmas varies on different trees—from 0.52 to 26.52 per cent for Group A and from 0.36 to 20.80 per cent for Group B.



GRAPH III (*d*). Showing the flower behavior of avocado varieties under Group A.

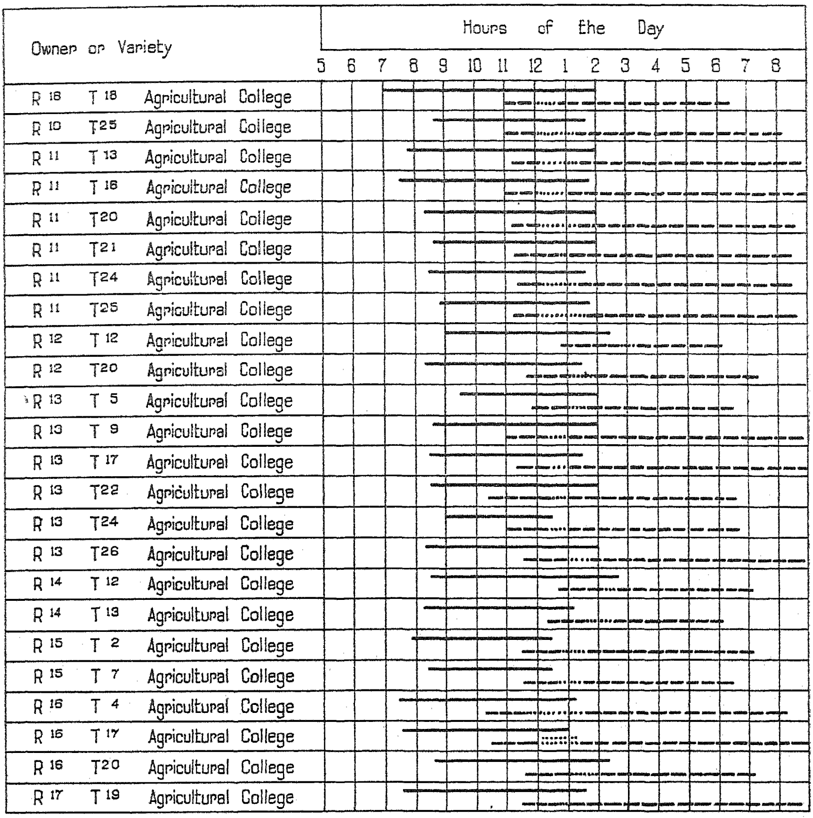
The production of fruits of isolated trees where there is no possible cross-pollination with other varieties or overlapping of the opening periods is undoubtedly due to the freshness and receptiveness of the stigmas and the nondehiscence of pollen during the second opening period of the flowers. Under such condition, however, the fruits produced in each of the flower panicles were fewer in number than on trees where cross-pollination or overlapping of the opening periods occurred.

Observations of the flower behaviors of the different avocado varieties were taken during the months of November, January, February, March, April and May. Of the varieties in Group A the Quality, Family, Commodore, Lyon in Los Baños, Dickinson, La Carlota No. 7 and 53 unnamed varieties had the receptiveness of their stigmas overlapped with the dehiscence of their pollen—in short, they are self-compatible varieties. Fifty-seven trees of this group have their first and second openings overlapped but that the receptiveness of their stigmas and the dehis-



GRAPH III (*e*). Showing the flower behavior of avocado varieties under Group A.

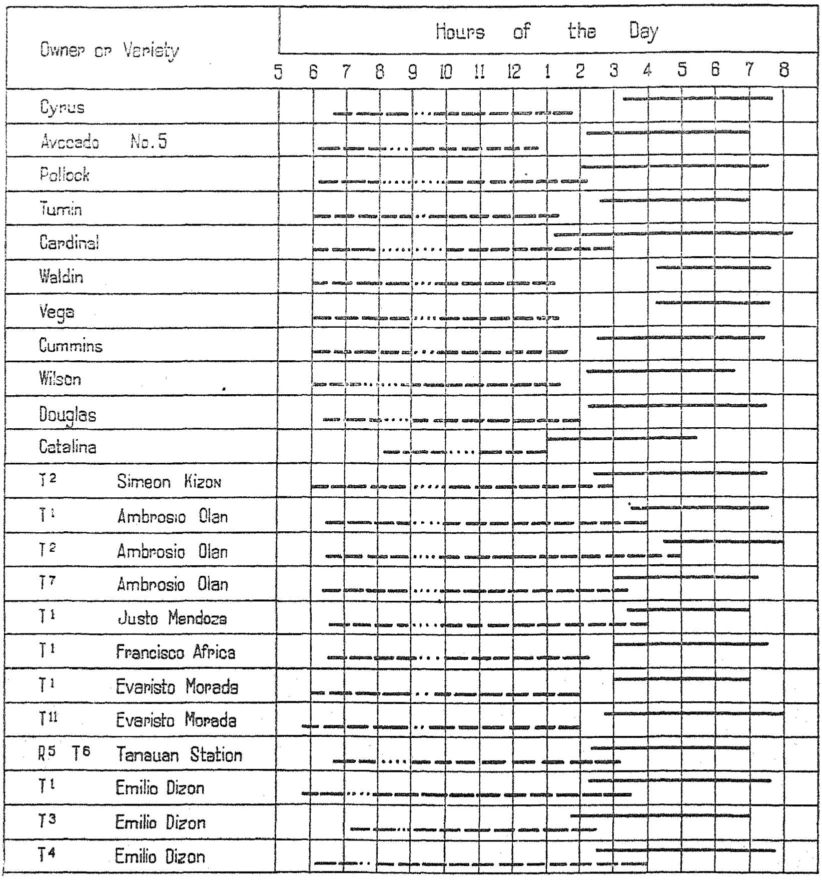
cence of their pollen do not coincide and 12 trees exhibited no overlapping whasoever. In Group B no self-compatible varities were found. However, the first and second opening periods overlapped on 57 trees, and no overlapping whatsoever on 67 trees. One of the controlling factors for the successful setting of fruits of avocados is the overlappings of the two opening periods of the flowers of a given variety or tree in which the receptiveness of the stigma and the dehiscence of pollen coincide. But although the two periods may overlap yet no fruits would set if the flowers that opened for the first time would close before the dehiscence of pollen during the second opening as for instance in the case of Avocado No. 1, Wester, Cyrus and Unnamed variety. However, of the self-compatible varieties just mentioned the flowers that opened for the second time will be capable of pollinating the incoming flowers in the same tree whose first opening coincides with the former and so on. No overlapping whatsoever has occurred on the Lyon and Com-



GRAPH III (*f*). Showing the flower behavior of avocado varieties under Group A.

modore varieties. In this group, varieties with late closing of the first opening period can be interplanted with the early pollen dehiscence varieties such as the Quality with the Avocado No. 1, Wester, Family, Dickinson, Cyrus, or La Carlota No. 7. The flowers of the Dickinson opened two hours earlier than those of La Carlota No. 7 and therefore there was some chances for the first-period flowers of the late La Carlota No. 7 to be pollinated by the flowers of the earlier Dickinson avocado. The flowers of Avocado No. 5 opened two hours earlier than the Vega variety.

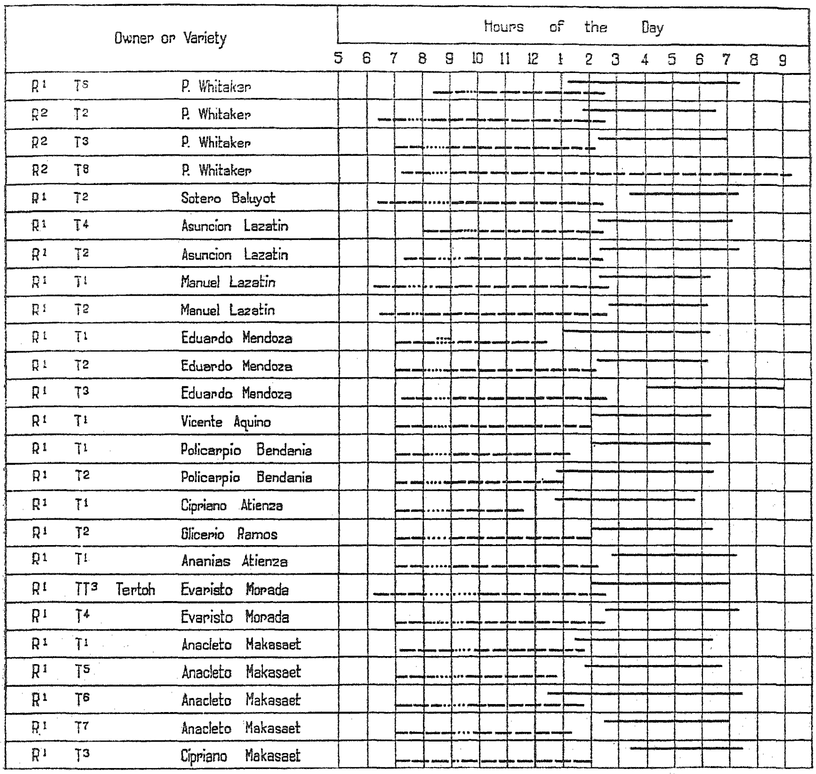
Of the best avocado varieties so far examined the Family, Lyon and the Wester of Group A should be interplanted with the Cardinal and Pollock of Group B. In the latter group no overlapping of the two opening periods occurs and therefore any variety planted in this group should necessarily be mixed with one or more varieties belonging to Group A.



GRAPH IV (*a*). Showing the flower behavior of avocado varieties under Group B.

Robinson and Savage and Stout have placed the Dickinson, the Wester, and the Family avocados under Group A, and the Lyon, Cardinal, Tumin, Waldin and Pollock under Group B.

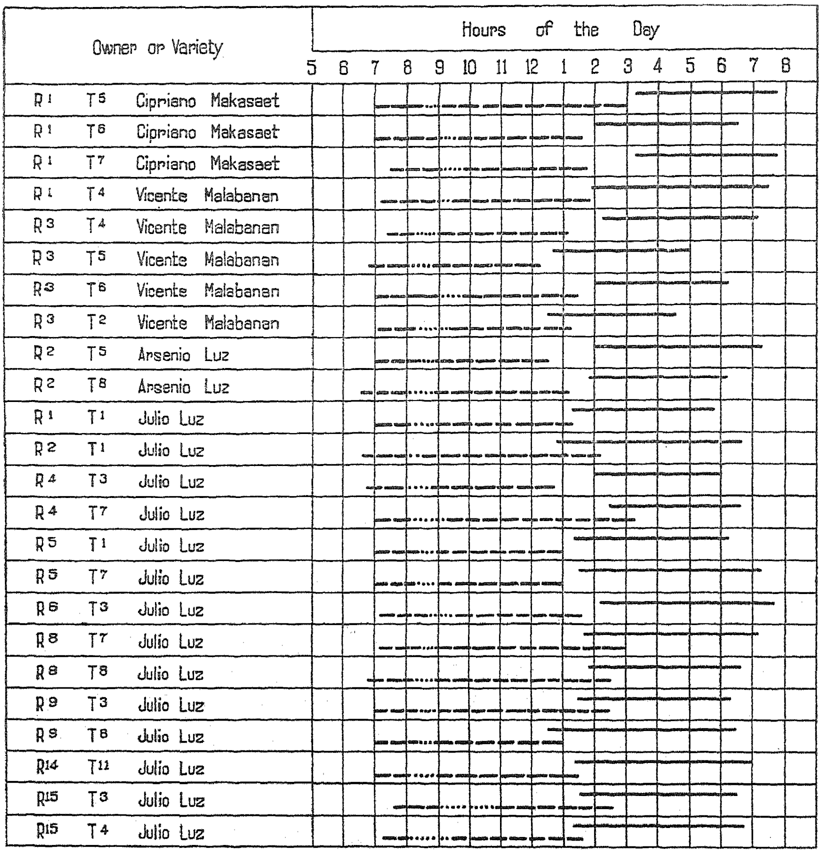
As regards the named varieties found fruiting in Batangas province and in Lamao, Bataan, both budded and seedling trees, as for example, the Lyon behaved differently. The Lyon although it falls under Group A yet in Lamao it falls under class two while in Tanauan in class three. Moreover, budded trees behaved differently too. A budded tree of the Pollock and a seedling tree of the Cardinal fall under Group B of class 2 and two budded plants of Pollock and Cardinal and a Cardinal seedling fall under class one of Group B. These different flower behaviors of the same variety may be either due to the environ-



GRAPH IV (*b*). Showing the flower behavior of avocado varieties under Group B.

mental factors or to the variations resulting from planting seedlings, or to the influence of the stock itself.

The different varieties in a group when propagated asexually have maintained their class flower behavior even under different soil and climatic conditions as for instance, the Cardinal and Pollock of Group B, and Lyon and Family of Group A. These varieties have behaved in the same way in Lamao and in Batangas. On the other hand, the seedlings and the budded plants of the Cyrus avocado even under the same conditions have behaved differently—the seedling trees fall under Groups A and B and the budded plants under Group B. This is also true in the case of Commodore where the budded plant falls under Group A while the seedling tree under Group B. Generally speaking, however, the weather conditions during the course of these observations were rather uniform except when the flowers of the Cummins avocado were under study, the weather was then rather cloudy and with intervening showers. Such a



GRAPH IV (*c*). Showing the flower behavior of avocado varieties under Group B.

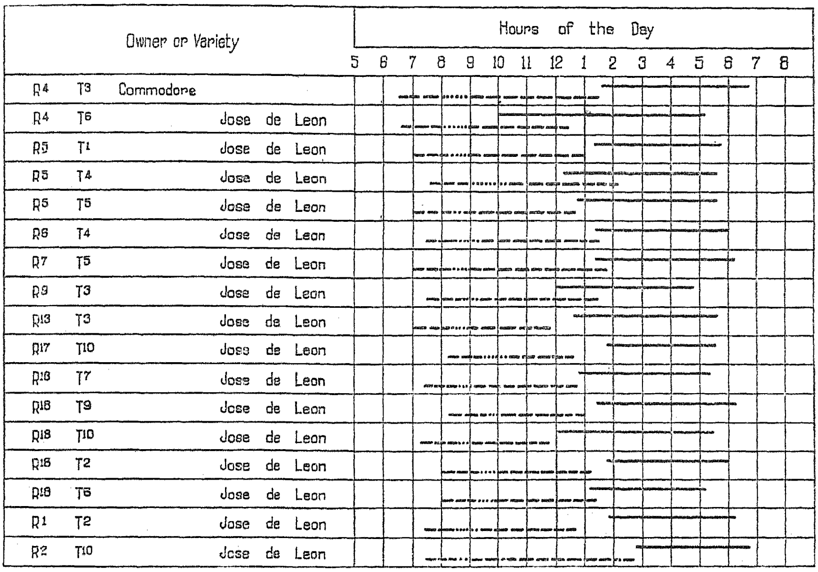
weather condition has retarded somewhat the opening and the closing of the flower of this variety. Furthermore, the rains started rather early in 1934.

In this study and as a guide for the avocado planters we have grouped the avocado varieties into two, as follows:

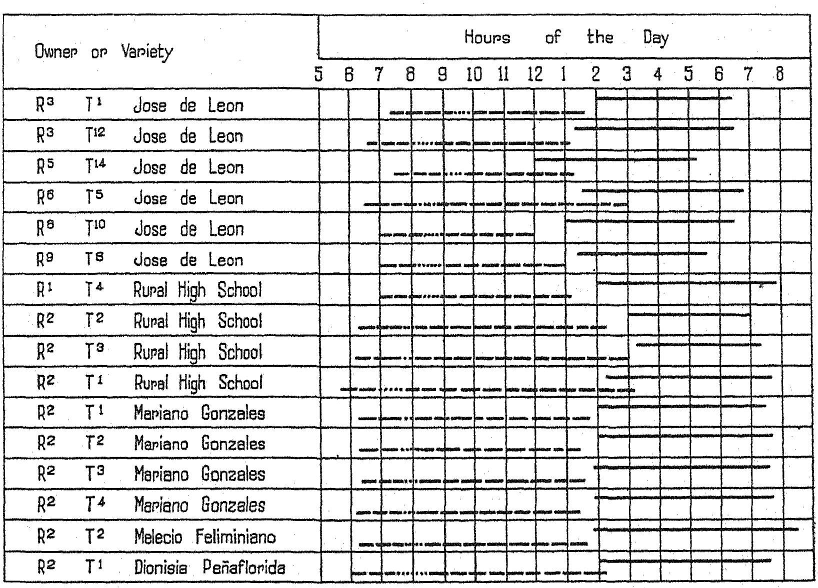
GROUP A.—Varieties whose first opening of flower is in the morning when the flowers function as females. This group has been subdivided further into three classes.

Class 1.—Varieties in which overlapping is occurring and the receptiveness of the stigma and the dehiscence of pollen coincide as for instance the Quality, Family, Dickinson, La Carlota No. 7, Commodore, and 51 trees of the unnamed varieties.

Class 2.—Varieties in which no overlapping of the two periods of opening occurs in the same tree. To this class belongs nine trees of the unnamed varieties.

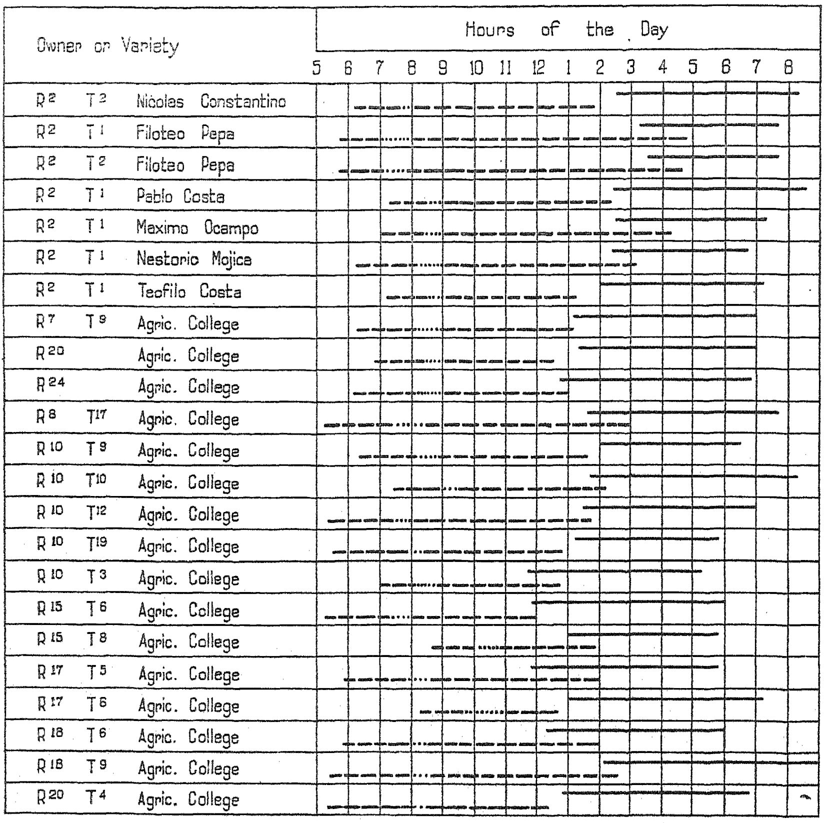


GRAPH IV (*d*). Showing the flower behavior of avocado varieties under Group B.



GRAPH IV (*e*). Showing the flower behavior of avocado varieties under Group B.

Class 3.—Varieties in which flower opening overlap but the receptiveness of the stigma and dehiscence of pollen do not coincide like the Avocado No. 1, Wester, Lyon, Cyrus (seedling), Lopena, and 64 unidentified trees.



GRAPH IV (*f*). Showing the flower behavior of avocado varieties under Group B.

GROUP B.—Varieties whose first opening of flower is in the afternoon when the flowers function as females and as males in the following morning. All varieties in this group fall under Class 2 and 3. Of Class 2 belong the Cardinal (budded and seedling), Cyrus (budded and seedling), Pollock (budded, grafted and seedling), Tumin, Wilson, Douglas, Avocado No. 5, Waldin, Vega, Cummins, Catalina, and 58 unidentified trees; and of Class 3 the Pollock (budded), Cardinal (seedling), and 57 unidentified trees.

SUMMARY

Fifty-nine trees consisting of 15 named and 29 unnamed varieties of avocado were observed during the 1933–34 flowering season in Lamao, Tanauan, Lipa and Mataas-na-kahoy. And during the 1934–35 flowering season 31 named and 217 unnamed trees were studied in Batangas, Bulacan, Cavite and Pampanga.

A study was made of the leaf buds and the flower buds. The flower buds are rounded and the scales and transition leaves developed more slowly than the leaf buds and are somewhat abnormal in size. The flower buds appeared early in August and were fully developed flowers from November up to May. In 1933–34 it took from 64 to 147 days for the flower buds to develop into panicles and 30 to 106 days for the panicles to the last appearance of the flowers, and in 1934–35 from 21 to 79 days and from 25 to 140 days, respectively. The majority of the flower buds originated from the terminal ends of the twigs; a few cases come from the axil of the leaves of the previous season growth and from large branches.

On heavy bearing trees practically all the twigs flowered. The flower panicles produced at the ends of the twigs were generally more vigorous than those produced elsewhere. The flower panicles borne at the tip of the terminal shoots contained an average of 162.9 florets and 203.8 for the panicles on the lateral twigs, but the peduncles of the former are longer and more stocky than the latter.

During the flowering season the trees were either heavily or slightly defoliated depending upon the number of flowers produced, and the formation of flowers was immediately followed by the development of new leaves with the exception of Family and a seedling of the Cyrus avocado where no leaf-fall occurred. Budded and seedling trees of the same variety may vary in the extent of their leaf-fall.

The avocado flowers are perfect and borne in clusters. They have two distinct periods of opening and closing, except those of one of the trees, owned by Mr. Whitaker, of Pampanga, which exhibited but one opening period. The stigma is receptive during the first opening and the pollen is shed during the second opening period. At the receptiveness of the stigma the corolla, nectaries and stamens lie in a flat plane or horizontal position. However, during the second stage or when the pollen was shed these flower parts were no longer in this position but rather slanting or hanging in outward direction.

The life cycle of an individual flower is longer in Group A than in Group B—34 against 24 hours in favor of the former.

The length of time for the opening of the flower, the dehiscence of pollen and the receptiveness of the stigma depends upon the variety and to the weather conditions, for climate influences the behaviors of the flowers. Budded and seedling trees sometimes behave differently too.

TABLE 5.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group A.*

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers: Observed	With receptive stigma	Without receptive stigma	Per cent of receptive stigma
R3T6	Unnamed	P. Whitaker	San Juan, San Fernando, Pampanga	S	372	25	347	6.72
R1T1	Lyon	Sotero Baluyot	San Fernando, Pampanga	S	474	31	443	6.54
R2T1	do	do	do	S	279	13	266	4.66
R1T2	Unnamed	Ramon Manio	San Marcos, Calumpit, Bulacan	S	240	13	227	5.42
R1T9	Lyon	do	do	B	115	0	115	0
R4T6	Unnamed	do	do	B	172	6	166	3.49
-T1	do	Isabel Aquino	Sambat, Taal, Batangas	S	352	0	352	0
-T1	do	Geronimo Rivera	do	S	295	20	275	6.78
-T1	do	Bibiano Kara	do	S	365	3	362	0.82
-T4	do	Cipriano Atienza	do	S	204	7	197	3.43
-T12	do	Evaristo Morada	Lipa, Batangas	S	226	12	214	5.31
-T3	do	Anacleto Makasaet	Pinagtungulan, Lipa, Batangas	S	162	4	158	2.47
-T4	do	do	do	S	250	3	247	1.20
-T1	do	Doroteo Makasaet	do	S	110	1	109	0.90
-T2	do	do	do	S	255	2	253	0.78
-T3	do	do	do	S	239	0	239	0
-T1	do	Cipriano Makasaet	do	S	186	4	182	0.78
-T2	do	do	do	S	210	3	207	1.43
R1T2	do	Vicente Malabanan	Balaknin, Lipa, Batangas	S	226	8	218	3.54
R1T3	do	do	do	S	157	2	155	1.27
R2T1	do	do	do	S	332	16	316	4.82
R3T2	do	do	do	S	378	0	378	0
-T1	do	do	do	S	125	9	116	7.20
-T3	do	do	do	S	276	5	271	1.81
R1T6	do	Arsenio Luz	Balete, Lipa, Batangas	S	119	9	110	7.56
R2T4	do	do	do	S	167	10	157	5.98

R2T7	do	do	do	S	219	5	214	2.27
R3T1	do	do	do	S	140	0	148	0
R3T2	do	do	do	S	174	0	174	0
R3T4	do	do	do	S	120	0	120	0
R1T3	do	Julio Luz	do	S	104	0	104	0
R2T4	do	do	do	S	189	13	176	6.88
R2T6	do	do	do	S	179	0	179	0
R4T1	do	do	do	S	137	11	126	8.03
R5T2	do	do	do	S	184	0	184	0
R6T5	do	do	do	S	186	9	177	4.84
R6T8	do	do	do	S	555	34	521	6.13
R13T2	do	do	do	S	147	8	139	5.44
R14T10	do	do	do	S	359	16	293	5.18
R15T9	do	do	do	S	205	6	199	2.93
R2T6	Family	Jose de Leon	Bañga, Talisay, Batangas	B	277	0	277	0
R3T8	Lyon	do	do	B	173	0	173	0
R6T3	Unnamed	do	do	S	174	0	174	0
R6T5	do	do	do	S	193	0	193	0
R9T2	do	do	do	S	150	0	150	0
R11T1	Lyon	do	do	B	196	0	196	0
R11T6	do	do	do	S	153	0	153	0
R11T9	Unnamed	do	do	B	229	0	229	0
R12T3	do	do	do	B	280	0	280	0
R12T4	do	do	do	B	165	16	149	9.70
R12T6	do	do	do	B	177	0	177	0
R12T9	do	do	do	B	208	0	208	0
R12T10	do	do	do	B	359	0	359	0
R14T9	do	do	do	B	288	0	288	0
R15T9	do	do	do	B	248	0	248	0
R16T5	do	do	do	B	234	0	234	0
R16T9	Commodore	do	do	B	322	0	322	0
R16T10	do	do	do	B	213	12	201	5.63
R17T8	Unnamed	do	do	B	243	0	243	0
-T1	do	do	do	S	94	0	94	0

NOTE.—B stands for budded plants, S for seedlings.

TABLE 5.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group A*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
–T3	Unnamed	Jose de Leon	Bañga, Talisay, Batangas	S	173	0	173	0
–T4	do	do	do	S	165	0	165	0
–T7	do	do	do	S	159	0	159	0
R1T4	Lyon	do	do	B	210	0	210	0
R1T5	Unnamed	do	do	S	195	0	195	0
R1T11	do	do	do	S	288	2	286	0.69
R1T15	do	do	do	B	240	0	240	0
R2T14	do	do	do	B	290	0	290	0
R3T6	do	do	do	B	305	0	305	0
R3T9	do	do	do	B	244	0	244	0
R6T2	do	do	do	B	210	0	210	0
R6T3	do	do	do	B	148	0	148	0
R6T5	do	do	do	B	189	0	189	0
R6T8	do	do	do	G	166	0	166	0
R7T15	do	do	do	B	315	0	315	0
R8T10	do	do	do	Stock	276	0	276	0
R15T6	do	do	do	B	161	0	161	0
R15T9	do	do	do	B	169	0	169	0
R16T7	do	do	do	B	158	0	158	0
R1T1	do	Rural High School	Indang, Cavite	S	253	15	238	9.80
R1T5	do	do	do	S	279	74	205	26.52
–T1	do	Melecio Feliminiano	do	S	137	5	137	0
–T1	do	Francisco Creencia	do	S	111	13	98	11.71
–T1	do	Rosario Cruz	do	S	144	0	144	0
–T2	do	do	do	S	176	0	176	0

-T1	do	Nicolas Constantino	do	S	153	0	153	0
-T1	Family	Constancia Alano	do	S	268	31	237	11.57
-T1	Unnamed	Jose Zalazar	do	S	135	16	119	11.85
-T1	do	Simeon Madlansakay	do	S	271	23	248	8.49
-T2	do	Teofilo Casta	do	S	243	30	213	12.35
-T3	do	Agustin Creencia	do	S	114	9	105	7.89
-T5	do	do	do	S	126	14	112	11.11
R7T4	Lyon	Agricultural College	Los Baños, Laguna	B	119	12	107	10.08
R7T5	do	do	do	B	118	4	114	3.39
R8T20	Unnamed	do	do	S	93	0	93	0
R9T22	do	do	do	B	112	0	112	0
R10T3	do	do	do	S	236	0	236	0
R10T4	do	do	do	S	125	0	125	0
R10T5	do	do	do	S	126	0	126	0
R10T15	do	do	do	S	147	0	147	0
R10T18	do	do	do	B	126	0	126	0
R10T25	do	do	do	B	190	0	190	0
R11T13	do	do	do	B	147	0	147	0
R11T16	do	do	do	B	196	0	196	0
R11T20	do	do	do	B	97	0	97	0
R11T21	do	do	do	B	87	0	87	0
R11T24	do	do	do	B	129	0	129	0
R11T25	do	do	do	B	113	0	113	0
R12T12	do	do	do	B	223	0	223	0
R12T20	do	do	do	B	137	4	133	2.92
R13T5	do	do	do	B	79	0	79	0
R13T9	do	do	do	B	99	0	99	0
R13T17	do	do	do	B	86	0	86	0
R13T22	do	do	do	B	99	3	96	3.03
R13T24	do	do	do	B	38	3	35	5.36
R13T26	do	do	do	B	60	0	60	0
R14T12	do	do	do	S	206	0	206	0
R14T13	do	do	do	S	192	1	191	0.52
R15T2	do	do	do	S	153	8	145	5.23

NOTE.—B stands for budded plants, S for seedlings, and G for grafted plants.

TABLE 5.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group A*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R15T7	Unnamed	Agricultural College	Los Baños, Laguna	S	52	1	51	1.92
R16T4	do	do	do	S	331	0	331	0
R16T17	do	do	do	B	294	0	294	0
R16T20	do	do	do	B	43	0	43	0
R17T19	do	do	do	B	34	0	34	0

NOTE.—B stands for budded plants, S for seedlings, and G for grafted plants.

TABLE 6.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group B.*

R1T6	Unnamed	P. Whitaker	San Juan, San Fernando, Pampanga	S	498	15	483	3.01
R2T2	do	do	do	S	356	21	335	5.90
R2T3	do	do	do	S	238	16	222	6.72
R2T8	do	do	do	S	301	10	291	3.32
R1T2	do	Sotero Baluyot	San Fernando, Pampanga	S	520	35	485	6.73
–T2	do	Asuncion Lazatin	Mexico, Pampanga	S	232	17	215	7.33
–T4	do	do	do	S	213	11	202	5.16
–T1	do	Manuel Lazatin	Talabaskagan, S. Fernando, Pampanga	S	370	18	352	4.86
–T2	do	do	do	S	332	15	317	4.52
–T1	do	Eduardo Mendoza	Sambat, Taal, Batangas	S	328	9	319	2.74
–T2	do	do	do	S	280	26	254	9.29
–T3	do	do	do	S	367	9	358	2.45
–T1	do	Vicente Aquino	do	S	252	10	242	3.97
–T1	do	Policarpio Bendania	do	S	300	24	276	8.00
–T3	do	do	do	S	326	13	313	3.99

-T1	do	Cipriano Atienza	do	S	380	3	273	0.79
-T2	do	Glicerio Ramos	do	S	234	5	229	2.14
-T1	do	Ananias Atienza	do	S	341	20	321	5.87
-T3	Tertoh	Evaristo Morada	Lipa, Batangas	S	276	5	271	1.80
-T14	Unnamed	do	do	S	252	14	238	5.56
-T1	do	Anacleto Makasaet	Pinagtungulan, Lipa, Batangas	S	179	6	173	3.35
-T5	do	do	do	S	178	1	177	0.56
-T6	do	do	do	S	170	3	167	1.76
-T7	do	do	do	S	198	11	187	5.56
-T3	do	Cipriano Makasaet	do	S	190	8	182	4.21
-T5	do	do	do	S	264	27	237	10.23
-T6	do	do	do	S	207	11	196	5.31
-T7	do	do	do	S	232	10	222	4.31
R1T4	do	Vicente Malabanan	Bulaknin, Lipa, Batangas	S	220	3	217	1.36
R3T4	do	do	do	S	305	20	285	6.56
R3T5	do	do	do	S	229	20	209	8.73
R3T6	do	do	do	S	277	22	255	7.94
-T2	do	do	do	S	170	3	167	1.76
R2T5	do	Arsenio Luz	Balete, Lipa, Batangas	S	271	0	271	0
R2T8	do	do	do	S	381	24	357	6.30
R1T1	do	Julio Luz	do	S	296	7	289	2.40
R2T1	do	do	do	S	368	2	366	0.54
R4T3	do	do	do	S	312	0	312	0
R4T7	do	do	do	S	295	0	295	0
R5T1	do	do	do	S	256	0	256	0
R5T7	do	do	do	S	289	2	287	0.69
R6T3	do	do	do	S	200	13	187	6.50
R8T7	do	do	do	S	228	19	209	8.33
R8T8	do	do	do	S	165	0	165	0
R9T3	do	do	do	S	449	23	426	5.12
R9T8	do	do	do	S	101	0	101	0
R14T11	do	do	do	S	410	24	386	5.85
R15T3	do	do	do	S	173	0	173	0
R15T4	do	do	do	S	243	2	241	0.83

TABLE 6.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group B*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R3T1	Pollock	Jose de Leon	Bañga, Talisay, Batangas	S	173	0	173	0
R3T4	Cardinal	do	do	B	274	0	274	0
R3T5	do	do	do	B	215	8	207	3.73
R3T7	do	do	do	B	103	6	97	5.83
R4T3	Commodore	do	do	S	277	1	276	0.36
R4T5	Cardinal	do	do	B	145	1	144	0.69
R4T6	Unnamed	do	do	S	188	0	188	0
R5T1	do	do	do	S	216	0	216	0
R5T3	Cardinal	do	do	S	267	2	265	0.75
R5T4	Unnamed	do	do	S	207	0	207	0
R5T5	do	do	do	S	243	0	243	0
R6T4	do	do	do	S	287	5	282	1.74
R7T5	do	do	do	S	227	11	216	4.85
R9T3	do	do	do	S	216	0	216	0
R10T3	Cardinal	do	do	B	225	0	225	0
R10T5	do	do	do	B	182	0	182	0
R13T3	Unnamed	do	do	B	304	0	304	0
R17T10	do	do	do	B	234	0	234	0
R18T1	Cardinal	do	do	B	205	0	205	0
R18T7	Unnamed	do	do	S	261	0	261	0
R18T9	do	do	do	S	171	0	171	0
R18T10	do	do	do	B	239	0	239	0
-T2	do	do	do	S	237	0	237	0
-T6	do	do	do	S	144	0	144	0
R1T2	do	do	do	S	247	0	247	0

R2T10	do	do	do	B	180	0	180	0
R2T15	Cardinal	do	do	B	310	0	310	0
R3T1	Unnamed	do	do	B	207	0	207	0
R3T12	do	do	do	B	230	0	230	0
R3T14	Commodore	do	do	S	201	3	198	1.49
R3T15	Cardinal	do	do	B	209	0	209	0
R4T7	do	do	do	B	215	0	215	0
R4T11	do	do	do	B	148	0	148	0
R4T12	do	do	do	S	226	0	226	0
R5T13	do	do	do	B	337	0	337	0
R5T14	Unnamed	do	do	B	270	0	270	0
R6T5	do	do	do	Stock	223	0	223	0
R7T5	Cardinal	do	do	B	342	2	340	0.58
R8T10	Unnamed	do	do	B	168	0	168	0
R8T15	Cardinal	do	do	B	215	0	215	0
R9T8	Unnamed	do	do	S	201	0	201	0
R1T4	do	Rural High School	Indang, Cavite	S	148	13	135	8.18
R2T2	do	do	do	S	245	19	226	7.75
R2T3	do	do	do	S	219	15	204	6.85
-T1	do	do	do	S	358	94	264	20.80
-T1	do	Macario Gonzales	do	S	158	16	142	10.13
-T2	do	do	do	S	160	22	138	13.75
-T3	do	do	do	S	133	19	114	14.28
-T4	do	do	do	S	150	13	137	8.67
-T2	do	Melecio Feliminiano	do	S	265	40	225	15.09
-T1	do	Dionisia Peñaflorida	do	S	347	68	279	19.60
-T2	do	Nicolas Constantino	do	S	195	17	178	8.72
-T1	do	Filoteo Pepa	do	S	202	21	181	10.40
-T2	do	do	do	S	130	13	117	10.00
-T1	do	Pablo Casta	do	S	187	23	164	12.30
-T2	Cardinal	do	do	B	232	16	216	6.90
-T1	Unnamed	Maximo Ocampo	do	S	253	28	225	11.05
-T1	do	Nestorio Mojica	do	S	139	12	127	8.63
-T1	do	Teofilo Costa	do	S	155	15	140	9.68

NOTE.—B stands for budded plants, S for seedlings.

TABLE 6.—*Showing the per cent of receptive stigma in the second opening period of avocado varieties in Group B*—Ctd.

Row and tree number	Variety	Owner	Address	Budded, grafted, or seedling	Total number of flowers			Per cent of receptive stigma
					Observed	With receptive stigma	Without receptive stigma	
R7T9	Unnamed	Agricultural College	Los Baños, Laguna	B	148	13	135	8.78
R7T20	do	do	do	B	126	0	126	0
R7T24	do	do	do	B	140	4	136	2.86
R8T17	do	do	do	S	221	2	219	0.90
R10T9	do	do	do	B	179	0	179	0
R10T10	do	do	do	B	245	0	245	0
R10T12	do	do	do	B	60	0	60	0
R10T19	do	do	do	B	185	0	185	0
R14T3	do	do	do	B	58	0	58	0
R15T6	do	do	do	S	114	9	105	7.89
R15T8	do	do	do	S	71	0	71	0
R17T5	do	do	do	S	74	0	74	0
R17T6	do	do	do	S	92	14	78	15.22
R18T6	do	do	do	S	108	0	108	0
R18T9	do	do	do	S	211	0	211	0
R20T4	do	do	do	S	243	0	243	0
R17T2	Cardinal	Bureau of Plant Industry	Lamao Horticultural Station	B	207	11	196	5.31
R18T5	do	do	do	B	163	12	151	7.36
R19T4	Cyrus	do	do	B	150	3	147	2.00
R20T1	Cummins	do	do	S	126	9	117	7.14

NOTE.—B stands for budded plants, S for seedlings.

The fresh stigmas during the second opening period varied in the different varieties—from 0.52 to 26.52 per cent in Group A and from 0.36 to 20.80 per cent in Group B. The production of fruits of isolated trees which was due to the freshness of the stigmas during the second opening period of the flowers was less than the production of the trees where cross-pollination or overlapping of the opening periods occurred.

Fruit setting in avocado is properly accomplished by interplanting reciprocating varieties in the orchard provided pollinating agencies are present.

Avocado varieties were grouped into two; namely, A and B, according to the time of opening and closing of their flowers. The A's open their flowers first in the morning and the B's in the afternoon, both reopening in the afternoon and morning of the following day, respectively. The varieties under each group are given, together with their respective classes.

Varieties that can be interplanted as well as the self-compatible ones are given.

RECOMMENDATIONS

1. To produce a maximum yield in avocado, under normal weather conditions interplanting of reciprocating varieties should necessarily be done, and it may be accomplished as follows:

(*a*) By the hill or row alternate planting. The former is adapted for the yard planting and the latter for orchard planting.

(*b*) By partly topworking the old trees in the orchard comprising but one variety with reciprocating varieties.

(*c*) By planting seeds. This is not recommended since sexually grown plants do not usually come true to type.

2. The varieties to be interplanted should have approximately the same flowering time—early varieties should not be interplanted with late varieties and vice-versa. The midseason varieties can be interplanted with either the early or late varieties.

3. Of the best locally grown avocados the Family, Lyon and Wester in Group A can be interplanted with the Cardinal and Pollock in Group B.

REFERENCES

1. NIRODY, B. S. Investigations in Avocado Breeding, California Avocado Association Annual Report (1922) 65–78.
2. STOUT, A. B. The Pollination of Avocados, University of Florida Agricultural Experiment Station, Bulletin No. 257, (March, 1933).

3. ROBINSON, T. RALP, and E. M. SAVAGE. The Pollination of the Avocado, United States Department of Agriculture (Circular No. 387, August, 1926).
4. VAN ELDEN. Speech delivered by Prof. Hodgson before the California Avocado Association, Year Book (1930) 30.
5. RYERSON, KOWLES. Avocado Culture in California, University of California Experiment Station, Bulletin No. 365, part I, pp. 36–37.

ILLUSTRATIONS

SIX YEARS OF TOBACCO BREEDING

By Mariano E. Gutierrez [1]

Agronomist, Bureau of Plant Industry

TEN PLATES

An earlier paper (1) prepared by the writer presented the reasons and the need of developing distinctly Philippine wrapper types, suited to our conditions, of medium-sized leaf and dual purpose breeds by hybridization. Of the native varieties, the Vizcaya, which approaches a wrapper type except for certain objectionable coarse characters and qualities, was chosen as female parent crossing it with Sumatra strain and constant hybrids thereof. The theme of that article served as the *raison d'etre* of the breeding work reported in the following pages.

Time and place.—This work was started and carried on for two seasons, 1928–29 and 1929–30, at Hacienda San Antonio of the Tabacalera, Ilagan, where the writer was employed for three years, and was continued for four seasons, 1930–31, 1931–32, 1932–33, and 1933–34, at the Ilagan Tobacco Station, Isabela.

THE CROSSING WORK: 1928–29 SEASON

The different parents used and hybrids made.—During this season, the work was crossing. In this large wrapper plantation with half a million Sumatra plants of six strains and a quarter of a million Vizcaya plants grown during the season, the work could be carried out with greater material and with more choice of parent plants than in a small plantation. The writer was given complete charge of seed selection and hybridization work, and had the whole plantation at his disposal to work on. The great number of Vizcaya plants was especially favorable for the choice of desirable plants for crossing. Since the five hybrids made had the object of improving the Vizcaya in the direction of wrapper production, the writer was guided

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by the description of Priego (2) in the selection of the pure Vizcaya type, which says:

Tabaco Vizcaya (*Nicotiana tabacum habanensis*).—Tallos herbáceous de 2 m. a 2.8 m. de altura, de hojas sentadas, auriculadas y abrazando el tallo en toda su circumferencia, las superiores enderezadas y lanceoladas, las inferiores horizontales y vales, acuminadas, lustrosas, verde claras y de gran desarrollo. Flores paniculadas, cáliz oblongo, con divisiones desiguales, corola tres veces más larga que el cáliz, embudada y de color purpureo.

Procede de Cuba y su introducción data del primer término del siglo (XIX). Se cultiva como una de las más preferidas por los cosecheros de la provincia (Isabela) y su nombre se refiere al antiguo de la misma.

It may be of interest to mention some facts regarding the varieties and constant hybrids used in this hybridization work.

Vizcaya.—Originally the seed of this variety came from the Valley of Magat, Isabela, and was in culture in the plantation for several seasons, and during this season, in the intensive Sumatra culture for wrapper production. Except when shaded with standard cheesecloth, it did not produce as great a percentage of wrappers as the Sumatra nor had the same desirable qualities. The type described by Priego could be easily distinguished in this large plantation. Owing to the elaborate wrapper culture, the plants grew superbly. This type served as the female parent of four of the crosses made. Some mosaic, of which this variety is very susceptible, appeared in some parts of the plantation. (Plate 1.)

Baker Sumatra.—This is the best Sumatra wrapper strain, the result of intensive selection in the defunct Pikit and Sarunayan Tobacco Stations, Cotabato, Mindanao, since its introduction in 1921. It produces the greatest percentage of fine wrappers with desirable colors and with the finest veins of all Philippine Sumatra strains. Under Cagayan Valley conditions, however, it produces mostly second length wrapper (30–38 cm.). The seed in pure condition was brought by the writer to the plantation. (Plate 1.)

Sumatra American-grown.—This was imported privately by the Tabacalera in 1928 from the United States. It looks much like an ordinary Sumatra and produces more fallow colored leaves. Conditions being equal, the leaves are smaller than those of the Baker Sumatra and are not so smooth or clean looking. The leaves cure with slightly more of the greenish cast than desired.

Philippine Sumatra.—This is Sumatra which was perhaps a mixture of the three Sumatra strains previously introduced into

the country from Sumatra; namely, Baker Sumatra, S. P. No. 1, and S. P. No. 2. It produces slightly coarser leaves than either the Baker Sumatra or the Sumatra American-grown. The present plantation was the result of mass selection in the preceding season.

Ax–11.—This is a constant strain of a cross made in Pikit, Cotabato, in 1922, with Baker Sumatra as the female parent and Florida Sumatra as the male parent(3). It has a vigorous rapid growth with somewhat narrow leaves but longer than the leaves of the Sumatras. It surpasses others in uniformity of color in the cured leaf. It produces the most fallow-colored leaves that are mostly first length. Its defects are its narrow breadth, index, 52 per cent, and slightly coarse veins. The leaves are carried to an acute angle. It has pinkish white flowers. (Plate 2.)

Bx–27.—It is a pure line and constant strain of the reciprocal cross of Ax–11 with Florida Sumatra as the female parent and Baker Sumatra as the male parent. It looks more like the Baker Sumatra, but with larger leaves and greater height. The marked distinguishing characteristic is the beautifully well diffused pink color of its large flat corolla. The leaves generally cure light brown and have an excellent flavor. Like the female parent, it is susceptible to mild mosaic infection, especially during the last stages of growth. Because of inherent good elasticity after proper fermentation, the mosaic leaves are not weak or badly blemished. (Plate 2.)

Both the Ax–11 and Bx–27 were also brought to the plantation by the writer.

The following hybrids were made during the 1926–29 tobacco season:

Symbol	Cross	Object
Fx	Vizcaya X Ax-11	To obtain light colors and greater elasticity.
Gx	Vizcaya X Bx-27	For greater breadth index, more rapid growth, and fine leaves.
Hx	Vizcaya X Baker Sumatra	For mosaic resistance and fine leaves.
Ix	Vizcaya X Sumatra American-grown	Fine veins and more fallow colors.
Kx	Philippine Sumatra X Vizcaya	For dual purpose.
Jx	Ax–11 X Sumatra American-grown	Fine veins and greater breadth index.

With the exception of the Jx-hybrid, all the other crosses have the Vizcaya with the object to improve it in the direction of wrapper leaf production for medium-sized wrapper leaf(1).

During the season of crossing, the Vizcaya plantation was infested with serious mosaic disease. The Baker Sumatra growing side by side with the Vizcaya was also infested with the disease, but not in so serious proportions. Therefore, in making the Vizcaya and Baker Sumatra cross with the object of mosaic resistance, the most resistant plants of both varieties in the worst infested lots were chosen for the crossing.

The technique of tobacco hybridization.—As many sets of from 10 to 20 plants were selected as there were number of crosses to be made, which were six. Every plant was labelled with a piece of *coco* cloth bearing in Chinese ink the plant number and the specific cross, as "25 Vizcaya × Baker Sumatra," meaning the figure for the number of the plant, the first name the female parent and the second, the male. In order that the numerous plants to be crossed could be properly attended, the writer trained a few very careful laborers to help him in this work. To avoid mistakes, the laborers were divided into groups, each group working on a specific cross day by day with the help and supervision of the writer. The groups carried lists of the number of female plants and when crossing and emasculation were finished on a particular plant, the number of the plant was checked for that date. In this way, all the plants of each cross could be pollinated and their new flowers emasculated. There were in all 124 female parents. The hybridization was made in the months of January and February, 1929.

The flower heads of the female and male parents were each enclosed with cheesecloth bag, 70 cm. long, made cylindrical with the aid of two wire No. 16 rings, 30 cm. in diameter. The bags were supported by small bamboo poles firmly thrust into the ground close to the plant with the cross pieces to suspend the bag. The bag was suspended at the upper end by means of a jute string; the bag could be raised as the plant grew higher. Some of the plants were very tall, necessitating the use of three-legged bamboo ladder in order to do the work well. (Text fig. 1.)

The flowers of the female parents were emasculated by simply splitting the corolla and removing all the stamens a day or two previous to the time when the stigma is in a receptive condition. During the emasculation, any flower that had any of its five stamens already burst or have burst during the operation was removed. Generally, emasculation was made when the tip of the closed corolla began to show slight signs of pinkish colo-

ration, or when the flowers have sufficiently developed but not yet open. Dehiscence generally begins at 5 to 8 a. m., depending upon whether the pollen sacks have sufficiently opened. On clear days, the pollen is dry and is in good condition for this work. The receptive condition of the stigma can be easily known by a change of color from green to dirty white, by its swollen appearance and moist condition. The pollen of the flowers from the male parents were simply touched to the stigma of the emasculated flowers of the female parents without the use of the fingers or any instrument. The work was mostly done between 5:30 to 11 a. m. The hybridization work on one plant required from 2 to 4 weeks. When sufficient pods have set, all the new flowers and flower buds were removed, the number of pods counted, and when matured were primed as in harvesting the leaves.

The pods were thoroughly dried separately for each cross in seed drying tables or in shallow boxes in the shade. After thorough drying, the pods were threshed, cleaned, and placed in bottles. Powdered napthalene were placed on top of the seeds, the bottles were corked, sealed with ordinary sealing wax, and stored for the next season.

THE F_1 GENERATION: 1929–30 SEASON

The seeds of the six different hybrids were sown separately in October, 1929. For the comparison, the different hybrids were planted side by side in a field of one wrapper grower.

During the F_1 generation, the plants of each hybrid were uniform and showed intermediate characters of the parents used.

During this season, the commercial wrapper plantation of three hectares, planted to other tobacco was attacked by mosaic disease, starting from the field of a careless grower and spreading all over the plantation. Since some of the hybrids were planted in the middle of the plantation, they naturally were infested also with the disease. Observations showed that among the hybrids, the Hx F_1 (Vizcaya × Baker Sumatra) was the least attacked.

Some notes were taken of the behavior of the hybrids in the field and the qualities of the finished leaves.

Fx F_1 (Vizcaya × Ax–11).—This hybrid appeared more like native tobacco. The plants showed intermediate characters of both parents. It produced the tallest plants among the hybrids and produced an average of 30.9 leaves per plant. It had a longer period of growth than Ax–11, almost behaving like the

Vizcaya. In general the cured and fermented leaves were of light brown color, lighter in color than the ordinary Vizcaya leaf, and had better elasticity.

Gx F_1 (*Vizcaya* × *Bx–27*).—The plants manifested rapid growth and great vigor with very broad and large leaves. It was the most striking of all the hybrids. At a glance the F_1 plantation was similar to Pampano, but different in having the smooth leaves, broad and erect when young, turning horizontal at maturity—a Vizcaya characteristic. Some of the plants after the flush of vigorous growth developed a mild infection of mosaic disease on the upper standard and top leaves. This mild mosaic disease may be due to poor nutrition during the last stages of growth, although it may also be due to some infection to which the plantation is exposed or to some disease inherent in the plant. This mild infection did not arrest the development of the plants as in a serious mosaic disease. It produced an average of 27.5 leaves per plant. The fermented leaves were fine with light color.

Hx F_1 (*Vizcaya* × *Baker Sumatra*).—This cross showed intermediate characters of both parents. The plants were of green color and the characteristic light color of the Vizcaya was not evident. The plants produced an average of 27.1 leaves per plant. The leaves cured well and produced a good proportion of fine and light colored leaves. As stated above, it was the least attacked by the serious mosaic infection that affected the plantation.

Ix F_1 (*Vizcaya* × *Sumatra American-grown*).—The plants showed intermediate characters of both parents. The green leaves were smooth with clean appearance. It produced an average of 27.5 leaves per plant. The fermented leaves showed more of the fallow color than any of the hybrids.

Jx F_1 (*Ax–11* × *Sumatra American-grown*).—This cross differed from the others in not having any native "blood." It was of the small wrapper leaf type, for improving the Ax–11 in some of its defects such as narrow leaves and coarse veins. It has very whitish pink flowers—an Ax–11 characteristic. A few plants had their flowers entirely white. The average number of leaves per plant was 23.1. Like the Ax–11 and the American Sumatra, it produced light fallow colored leaves after fermentation. It was the earliest maturing of the hybrids.

Kx F_1 (*Philippine Sumatra* × *Vizcaya*).—This cross showed about the same characters as the Hx F_1, being practically the reciprocal cross, except that the Sumatra female parent was not

the Baker Sumatra. The plants did not show as vigorous growth as the Hx F_1. It produced an average of 23.6 leaves per plant. The leaves cured fairly well with same light colored fine leaves.

The best plants of these hybrids were bagged for breeding. The number of plants selected from each cross were as follows: Fx F_1—20 plants; Gx F_1—36 plants; Hx F_1—64 plants; Ix F_1—40 plants; Jx F_1—36 plants; and Kx F_1—50 plants.

THE F_2 GENERATION: 1930–31 SEASON

Since the plantation was dedicated more to the commercial production of wrapper leaves, only two, the Gx and Jx hybrids, were chosen to be planted on a large scale. The two growers who planted the Gx F_2 had 27,595 plants and the other grower who planted the Jx F_2 had 8,845 plants. Some of the mass selected seeds and extra seedlings of these two hybrids and the others were given to some Hacienda tenants, the idea being to have them grow the hybrids and later to inspect their tobacco fields in order to make some initial selections. The rest of the selected seeds were kept.

Seed sowing in beds began on September 8 and was continued weekly for 5 weeks. On October 23, transplanting was started in the intensive Sumatra method of culture.

The Gx F_2 showed very great variability. The grand parental types of the male parent Bx–27, namely Florida Sumatra and Baker Sumatra, showed some representatives, although rare(4). Six good types were easily distinguished.

Type A.—Plants vigorous, Florida Sumatra-like, color dark green, with smooth, fairly elliptical leaves with obtuse tips, erect with acute angles of insertion. Good wrapper type. Somewhat early. Plants very rare. (Plate 4.)

Type B.—Similar to type A, except that the leaves at maturity are carried horizontally on the stem, with narrower leaves. There were more representatives than in type A. Fairly good wrapper type.

Type C.—Plants vigorous, Baker Sumatra-like, but morphologic characters in greater proportions; color, dark green. Young leaves with swollen appearance. Plants very rare. Good wrapper type.

Type D.—Plants very vigorous with rapid development; easily strikes the attention for having large broad leaves, like the native Pampano. This was the heterozygous type of the Gx in the F_1 generation. Good as a dual purpose type. (Plate 4.)

Type E.—Plants vigorous with light green color; leaves not as large as those of type D with somewhat yellow specks, a Bx–27 characteristic. Leaves somewhat swollen and wavy when young, turning smooth when mature.

Type F.—Plants Vizcaya-like with somewhat narrow pointed broadly-winged leaves with light to dark colors.

There were also other not well-defined types, which were discarded. Some of these were of doubtful value. One rare type that called forcibly one's attention is a plant with a rosette but with the leaf margin very wavy or surly, showing decorative effect.

Likewise, the Jx F_2 was segregated into Sumatra, intermediate, and Ax–11 types. The intermediate type was good for wrapper work.

In December, 1930, when this culture was pending, the writer left the employ of the company. As there was no disposition to continue the selection and purification work necessary in hybrids for the lack of a technically trained man at the plantation he made the suggestion that the two types A and B should be selected for wrapper work and type D for dual purpose of Gx hybrid, and the intermediate type of the Jx hybrid.

Late station culture of the F_2 generation.—As the F_2 culture at the plantation did not yet produce seeds at the time of his departure, he was given the F_1 seeds of the hybrids. Seed beds were made in January and the hybrids were planted in plots of 500 square meters each at the Ilagan Tobacco Station. Owing to the lateness of the season and consequent stunted development precluding the possibility of isolating the desirable mother plants from each cross and the limited plant population, no selection was made, reserving this work in the F_3 generation. Better selection could be made in the next generation with more plants grown in the right season to select from. Moreover, with an extra generation the promising hybrids could be known and the selection from these could be accordingly stressed. The best plants from each cross had their flower heads bagged and the seeds were stored for the next season.

THE F_3 GENERATION: 1931–32 SEASON

As above stated, no strain selections during the F_2 generation was made. For lack of sufficient seed, the Fx F_3 was cultured in a breeding plot consisting of the set of station and other hybrids. The Jx F_3 was cultured with the small-leafed Sumatra hybrids.

The Gx, F_3, Hx F_3 and Kx F_3 for medium-sized leaf wrapper, were cultured in duplicate plots of $\frac{1}{8}$ of a hectare each. Five standard seed beds for each cross were sown on October 12, 1931, and after 50 days, the seedlings were transplanted in the duplicate plots. The purpose of this test was to compare the behavior of these hybrids in the F_3 generation and to make the initial individual plant selections for certain desirable characters or quality, stressing the selections on the most promising among them. (Plate 5.)

The calculated yield per hectare and the percentage of marketable wrapper leaves for each cross were as follows: Gx F_3, 1,864 kilos with 24.7 per cent; Hx F_3, 1,140.8 kilos with 27.9 per cent; Ix F_3, 949.6 with 32.5 per cent; and Kx F_3, 692.8 with 13 per cent. In an earlier planting of Ix F_3 in our San Vicente Hill lot we obtained a yield of 1,063 kilos per hectare with 33.2 per cent wrapper. In this plot test, the following facts were observed: The best yielder with the largest leaves was the Gx F_3. The hybrid that gave the most percentage of marketable wrapper leaf was the Ix F_3, although the yield was not high, followed by Hx F_3. The poorest result as to yield and percentage of wrapper was obtained from Kx F_3 hybrid. The Hx F_3 was the least susceptible to mosaic infection, being only 0.8 per cent from a population of 3,744 plants. This being less than 1 per cent, was of no consequence even in a wrapper field.

Those fairly large duplicate plots of $\frac{1}{8}$ of a hectare each, or $\frac{1}{4}$ of a hectare devoted to each hybrid in this test and the other lot of Ix F_3 consisting of 2,770 square meters in the early hill planting afforded us with sufficient material to make our initial selection for line work.

In this generation the same types in the Gx F_3 as enumerated in the F_2 were found. (Figs. 5 and 6.) The Ix F_3 showed also considerable variability and a few specific types may be described as follows:

Type A.—Good wrapper strains with large and broad leaves, but rather rare.

Type B.—Strains with leaves not as broad as the first type carried at an acute angle. Also rare.

Type C.—Sumatra-like early strains with small leaves.

Type D.—Late flowering strains with many close-set leaves, carried horizontally at maturity with more Vizcaya characters.

Type E.—Intermediate type partaking characteristics of both parents, leaves fairly long and borne far apart.

There were also poor and worthless types which were discarded.

In the Hx F_3 and Kx F_3 there were not so much variability as shown by Gx F_3 and IX F_3. However, in the Hx F_3, besides the intermediate and a few other types, there were found very late strains with numerous close-set small leaves, but larger than Sumatra leaves.

The lower and middle standard leaves of the selected plants were harvested and labelled separately, cured, and fermented. While the living plant may appear perfect, its fermented leaves may be defective in any of the important particulars, such as, texture, venation, color, elasticity, and other desirable features in the finished leaf. This is carrying the selection of desirable plants one step farther, and is carried less erringly, because the final decision of the value of selected tobacco strain lies in the industrial value of the leaf. This close scrutiny is the more necessary in a hybrid strain than in a strain selected from a standard variety—especially on the product of the progeny of selected mother plants—as the varying character or quality may be due to heterozygosity. The homozygous lines for certain characters or quality can be better isolated, besides the uniformity shown in the best rows, by the uniformity of the fermented leaf, because the characters or qualities seen in the finished product are hidden from the eye in the green leaves however perfect they may look. A pertinent illustration of this method of rigid selection will be given in the discussion of test row results. It is for the reasons above mentioned that many of our initial selections were at once discarded without the necessity of culturing them, because of serious defects in their fermented leaves.

THE F_4 GENERATION: 1932–33 SEASON

A number of selections were sown in beds on October 11, 1932, allowing one strain for every 5-square-meter bed. This separate sowing precluded seed mixing. The seeds of the following selections were sown separately:

Cx F_4—32 selections, Ix F_4—32 selections, Hx F_4—18 selections, and Kx F_4—6 selections.

There were therefore originally sown in seed beds 88 selections of four hybrids.

During the seed-bed period, the weather was so abnormal because of the continuous and excessive rainfall and the three successive storms of October 24, November 11, and December 6, 1932. Consequently, our seed beds suffered severe losses in seedlings. After the first storm, the selections that had remnant seeds were replanted; in other cases there were no more seeds to replant. There were also some numbers where only a few seedlings survived after the bad weather. In view of these losses we could not carry out our original plan of running sufficiently replicated test rows of all the 88 selections.

Plant-to-the-row tests—Duplicated.—The next best thing to do was to select the numbers with more than 200 seedlings surviving for each selection, and then to run duplicate rows of 100 plants each in Plots A and B. One row of each strain appeared in the same order in both dots. The following were the selections cultured in these duplicated plant-to-the-row tests:

Gx F_4–14, –16, –19, –30, –34, –43, –48, –51, –56, or 10 strains.
Hx F_4–1, –3, –9, –16, –17, or 5 strains.
Ix F_4–1, –2, –3, –4, –5, –12, –14, –16, –17, –20, –21, or 11 strains.

There were 26 selections tested of three hybrids only.

The extra seedlings from the above mentioned plant-to-the-row tests and others of the replanted seed beds were planted in Plot D in rows or in plots as the number of seedlings warranted. There were two reasons for doing this. If some of the test rows should eventually be selected, we would have an extra plot to get more seed from. In this way, we would be doing for the valuable strains during this season the work of two seasons, to retrieve our lost work in the F_2 generation. These plots of extra seedlings should give corroborative or other data for our duplicate test rows. The numbers appearing in varying number of rows in Plot D were the same as those in Plots A and B.

All the other numbers that could not give sufficient seedlings for duplicate rows were planted in Plot C. The object was to perpetuate for another season the seeds of these for another trial, should the test rows in Plots A and B fail to give us some results.

The outlay of our breeding plots may be seen in the following diagram:

100 METERS

	PLOT C	PLOT B	PLOT A
50 M.	Seed perpetuation plot; for one season only	Plant-to-the-row tests. Duplicate of Plot A	Plant-to-the-row tests

STATION ROAD (5 meters wide)

	PLOT D
50 M.	Multiplication and corroborative plot cultures

Transplanting in these plots began on December 10, 1932, and was continued until finished. Plots A and B were planted on the same day. Plants were uniformly spaced 90 cm. between rows and 50 cm. between plants for all plots. When the plants were about 30 cm. high, they were alternately cultivated with the small 5-tooth Calamba cultivator and the large Batangueño cultivator, in order to ridge the rows. After a series of two cultivations with these implements, the loose earth left between the rows were brought to the ridges by the tjankol (large Malayan hoe), thus rounding the ridges and making them better.

In this report of the F_4 generation we are mostly concerned with the results of our duplicate test rows in Plots A and B and the data presented refer to the strains cultured in them. Unfavorable conditions have narrowed our work to three, out of four, hybrids, which fortunately were good material to work on, as found out in our plot tests in the previous season. For corroboration of certain specific characters found in the test rows, we resorted to our Plot D. In this way, what we lacked in more replications was partly supplied by our multiplication and corroborative plot cultures and the reported results were of more value.

Data secured from each test row.—From each test row, data were obtained which may be grouped as follows:

Stalk character;
Green leaf characters, quantitative and botanical;
Plant characters;
Diseases and pest data;

General test row data, including market distinguishing characteristic, if any;
Fermented leaf characters; and
Yield and percentage of wrapper leaves.

The above data were grouped in Tables 1 and 2. These data with some exceptions are generally obtained in the ordinary study of quantitative and qualitative characters in selections. Twenty plants picked at random from each test row were measured and studied and the average results with the errors of the mean are presented in Table 1.

"Wrapper production index."—Attention is invited to the recording of the number of leaves one meter from the ground. The principal reason for getting this is that this work is for wrapper production, and under normal conditions, the performance of the plant one meter from the ground is a good index of its capacity for wrapper production. In any wrapper variety or strain, the fine wrapper leaves are found in this region, where the sand, lower, and middle standard leaves are located; above this region the upper standard and top leaves are generally found, and these are to be considered as wrapper leaves. If the circumference of the stem, the length of internode, and more especially the *number of leaves* are known 1 meter from the ground, the wrapper leaf production can be roughly gauged. In order to see this clearly for the number of leaves only, the writer advances a way of expressing it in terms of percentage, and for want of a better term, may be called "wrapper production index." This is obtained by dividing.

$$\frac{L}{1} \text{ by } \frac{TL}{H} \text{ multiplied by } 100$$

in which L represents the number of leaves 1 meter from the ground, 1 is the unchanging number for 1 meter, TL, total number of leaves of the plant and H, the whole height of the plant. For example, a plant has 20 leaves 1 meter above the ground, the total number of leaves is 40 and the plant has a height of 2 meters, then we have

$$\frac{20}{1} + \frac{40}{2} \times 100, \text{ or } \frac{20}{1} \times \frac{2}{40} \times 100 \text{ or } 100\%$$

When the wrapper production index is 100 per cent, there are as many leaves in the 1 meter region as above it and the plant may be considered a good wrapper leaf producer; when it is above 100 per cent the plant is an excellent wrapper leaf producer; and when it is less than 100 per cent the plant may be a poor producer of wrapper leaves.

TABLE 1.—*Showing stalk characters, green leaf characters, including botanical description, plant characters, and percentage attacked by mosaic and suspected mosaic.*

Hybrid name	Line number	Stalks characters					
		Average mean height	One meter from ground			Wrapper production index. Average	Average mean length internode
			Average mean circumference	Average mean length internode	Average mean number of leaves		
		cm.	*cm.*	*cm.*		*Per cent*	*cm.*
G×F4	14	242,4+1,809	8.4+0.097	6.75+0.127	14.95+0.194	122.8	8.3+0.201
G×F4	16	237.2+2.016	8.12+0.066	7.7+1.390	13.4+0.191	108.5	8.1+0.125
G×F4	19	219.5+3.286	7.7+0.075	7.2+0.119	13.8+0.121	110.1	7.8+0.094
G×F4	30	192.0+2.328	6.6+0.097	6.3+0.217	16.2+0.451	110.4	6.9+0.098
G×F4	34	183.3+1.972	7.6+0.085	4.2+0.061	24.8+0.155	132.5	5.3+0.718
G×F4	43	199.5+4.645	7.9+0.106	5.7+0.129	19.9+0.308	113.8	5.6+0.129
G×F4	48	198.0×1.775	7.4+0.808	6.6+0.118	15.9+0.231	110.0	7.2+0.115
G×F4	51	197.9+1.758	8.0+0.146	5.3+0.045	17.8+0.298	127.6	7.1+0.075
G×F4	55	215.6+4.192	7.7+0.097	6.2+0.264	17.4+0.501	135.0	7.9+0.144
G×F4	56	222.0+1.683	7.6+0.068	6.7+0.135	15.5+0.201	118.0	7.3+0.159
H×F4	1	198.0+2.187	8.2+0.086	3.9+0.083	28.6+0.221	132.0	4.8+0.075
H×F4	3	199.4+3.119	7.2+0.099	4.9+0.136	21.0+0.462	140.0	7.2+0.166
H×F4	9	184.8+1.994	7.8+0.056	4.3+0.075	25.0+0.357	135.0	5.4+0.071
H×F4	16	186.8+3.273	7.4+0.067	4.2+0.080	24.0+0.369	137.0	5.9+0.111
H×F4	17	200.3+0.189	6.9+0.091	5.4+0.097	21.4+0.278	126.0	5.9+0.111
I×F4	1	211.6+2.036	8.9+0.110	6.9+0.062	16.4+0.151	111.9	6.7+0.108
I×F4	2	206.7+1.453	7.1+0.065	8.1+0.106	14.0+0.144	115.7	8.6+0.087
I×F4	3	222.5+1.433	7.6+0.068	8.2+0.136	14.8+0.175	124.0	8.3+0.070
I×F4	4	220.3+1.900	7.6+0.088	7.5+0.133	16.5+0.392	135.1	7.8+0.120
I×F4	5	205.7+2.845	8.7+0.088	6.8+0.097	16.4+0.221	115.9	6.9+0.129
I×F4	12	194.3+1.871	7.5+0.069	5.0+0.157	23.6+0.403	136.6	5.8+0.090
I×F4	14	200.9+3.799	7.2+0.069	6.9+0.094	15.0+0.242	125.5	8.2+0.119
I×F4	16	202.8+2.623	7.7+0.187	6.5+0.083	17.5+0.228	111.6	6.4+0.960
I×F4	17	179.2+1.599	7.2+0.089	5.1+0.125	21.8+0.272	128.5	6.2+0.079
I×F4	20	201.9+2.413	7.1+0.106	7.2+0.099	14.9+0.097	113.9	7.6+0.087
I×F4	21	228.9+1.885	8.3+0.091	7.0+0.123	15.1+0.181	118.3	7.1+0.085

Hybrid name	Line number	Green leaf characters				
		Average mean total leaves	Average mean angle of insertion	Middle standards		
				Average mean length of leaves	Average mean breadth	Average mean breadth index
			Degrees	cm.	cm.	Per cent
G×F4	14	29.4+0.437	43.0+0.905	59.8+0.799	34.4+0.439	57.6+0.711
G×F4	16	29.3+0.551	45.8+1.116	56.9+0.613	33.9+0.652	58.6+0.875
G×F4	19	27.7+0.274	47.3+0.694	61.4+0.568	32.6+0.432	53.6+0.504
G×F4	30	26.9+0.369	46.7+1.158	54.2+0.965	31.3+0.718	57.9+0.652
G×F4	34	34.3+0.507	41.7+0.685	56.0+0.784	28.0+0.579	50.9+0.558
G×F4	43	34.0+0.785	59.0+0.685	57.0+0.677	32.5+0.479	57.2+0.678
G×F4	48	27.0+0.289	48.7+1.207	56.0+0.635	30.8+0.505	54.6+0.613
G×F4	51	27.6+0.337	49.2+1.222	62.1+0.471	35.3+0.606	56.7+0.606
G×F4	55	27.0+0.436	55.0+1.357	57.0+0.492	31.7+0.406	55.4+0.709
G×F4	56	29.0+0.722	49.0+1.014	60.6+0.548	32.8+0.406	53.9+0.533
H×F4	1	42.9+0.669	52.3+0.919	50.8+0.362	24.9+0.359	48.9+0.444
H×F4	3	29.9+0.845	51.8+0.691	48.1+0.121	27.6+0.443	57.5+0.626
H×F4	9	34.0+0.449	49.0+0.528	46.8+1.274	23.9+0.247	50.9+0.504
H×F4	16	32.7+0.546	53.5+0.679	50.8+0.096	26.6+0.346	52.2+0.634
H×F4	17	34.2+0.676	50.7+0.685	45.9+0.684	27.0+0.453	58.7+0.652
I×F4	1	31.0+0.181	48.8+0.709	56.7+0.483	35.3+0.377	62.2+0.577
I×F4	2	25.0+0.305	49.7+0.733	51.0+0.377	30.7+0.504	60.3+0.578
I×F4	3	26.5+0.259	54.5+0.711	56.9+0.754	28.3+0.471	48.5+0.606
I×F4	4	26.9+0.478	51.0+0.679	51.0+0.603	26.7+0.527	53.2+0.749
I×F4	5	29.1+0.231	46.0+0.685	55.3+0.445	32.4+0.444	58.5+0.503
I×F4	12	33.7+0.428	43.7+0.748	49.2+0.812	26.7+0.469	54.4+0.635
I×F4	14	24.0+0.196	44.5+0.108	48.7+0.626	25.7+0.377	52.7+0.406
I×F4	16	31.8+0.323	48.3+0.799	49.6+0.918	29.0+0.588	57.1+0.579
I×F4	17	30.4+0.397	49.3+0.961	49.3+0.649	26.8+0.483	51.6+0.799
I×F4	20	26.4+0.347	45.3+0.842	52.0+0.558	29.4+0.539	56.3+0.558
I×F4	21	29.2+0.343	54.8+0.879	58.3+0.579	32.3+0.444	55.4+0.539

TABLE 1.—*Showing stalk characters, green leaf characters, including botanical description, plant characters, and percentage attacked by mosaic and suspected mosaic*—Continued

Hybrid name	Line number	Green leaf characters								Plant characters				Disease
		Position of leaves (1)	Shape (2)	Surface (3)	Color (4)	Margin (5)	Base (6)	Petiole (7)	Apex (8)	Uniformity (9)	Form of plant (10)	Form of head (11)	Color of flowers (12)	Mosaic
														Per cent
G×F4	14	FE	Ov	FSm	LG	SU	AC	BW	A	U	Lan	Op	VLP, D	16.9
G×F4	16	FE	Ov	SW	G	SU	AC	BW	Obt	U	Lan	Cp	LP, D	15.5
G×F4	19	FE	Ov	SW	LG	SU	AC	BW	A	U	Lan	FCP	LP	18.4
G×F4	30	FE	Ov	W	G	SU	AC	BW	Obt	FU	Lan	FCp	LP, FD	19.9
G×F4	34	E	Ov	Sm	G	En	AC	BW	A	U	Con	Cp	WP	9.8
G×F4	43	H	Ov	VW	G	SU	AC	BW	A	U	Lan	Cp	LP	11.0
G×F4	48	FE	Ov	VW	LG	SU	AC	BW	A	U	Lan	CP	P	14.3
G×F4	51	H	Ov	Sm	G	SU	AC	BW	Obt	U	Lan	FCp	WpP	17.6
G×F4	55	FE	Ov	Sm	G	SU	AC	BW	A	NU	Lan	CP	P, D	21.4
G×F4	56	FE	Ov	Sw	LG	SU	AC	BW	A	U	Lan	Cp	P, FD	24.5
H×F4	1	E	Ov	Sm	G	SEn	AC	BW	A	U	Lan	Op	P	15.0
H×F4	3	E	Ov	Sm	G	En	AC	BW	A	U	Lan	Op	P	8.5
H×F4	9	E	Ov	Sm	G	SU	AC	BW	A	U	Lan	Op	P	24.2
H×F4	16	FE	Ov	Sm	DG	SU	AC	BW	A	U	Lan	Op	P	11.5
H×F4	17	E	Ov	SW	G	SU	AC	BW	A	U	NP	Op	P	29.9
I×F4	1	FE	Ov	SW	LG	SU	AC	BW	A	U	Cyl	Cp	WP, D	30.5
I×F4	2	FE	Ov	W	LG	SU	AC	BW	A	U	Lan	Cp	P	19.9
I×F4	3	H	Ov	W	G	SU	AC	BW	A	U	Lan	SOp	LP, D	12.4
I×F4	4	H	El	W	G	SU	AC	BW	Obt	NU	Lan	FOp	P, D	22.4
I×F4	5	FE	Ov	W	DG	En	AC	BW	Obt	U	Con	Cl	LP	14.9
I×F4	12	E	El	W	LU	SU	AC	BW	A	U	Lan	FCP	LP	39.4
I×F4	14	FE	Ob	Sm	G	SU	AC	BW	Obt	U	Lan	FCP	L, PD	42.5

I×F4	16	H	O	Sw	G	En	AC	BW	Obt	U	Lan	Ct	W, nD	52.6
I×F4	17	FE	Ov	W	G	En	AC	BW	Obt	U	Lan	Op	PW, nD	32.0
I×F4	20	FE	Ov	Sm	G	En	AC	BW	Obt	U	Lan	Cp	LP	47.8
I×F4	21	H	Ov	W	G	SU	AC	BW	Obt	U	Lan	Op	LP	31.4

(1) E=erect, EE=fairly erect, H=horizontal.
(2) Ov=ovate, ob=oblong, El=elliptic.
(3) Sm=Smooth, W=wavy, SW=slightly wavy, VW=very wavy, Swo=swollen.
(4) G=green, LG=light green, DG=dark green.
(5) En=entire, U=undulate, SU=slightly undulate.
(6) AC=auriculate clasping.
(7) BW=broadly winged.
(8) A=acute, Obt=obtuse.
(9) U=uniform, FU=fairly uniform, NU=non-uniform.
(10) Lan=lanceolate, Con=conincal, cyl=cylindrical, NP=nearly pyramidal.
(11) Op=open, Cp=compact, FCp=Fairly compact, SOp=slightly open Cl=closed.
(12) P=pink, LP=light pink, VLP=very light pink, D=diffused, FD=fairly duffused, WP=whitish pink, WpP=white patched with pink.

Importance of marked botanical characters.—There were also recorded some botanical characters common to the plants of each test row. This recording is the more necessary in hybrid strains than in line selections from standard varieties, because of the wider variation manifested in hybrid strains and because each homozygous strain or line may give rise to a new race(5). Moreover, in our tobacco work for many years, we were able to identify certain varieties and very often one or two distinguishing characters like plant form, color of flowers, the way the leaves are attached to the stem, etc., guided us in the practical separation or identification of standard varieties in mixed plantings without resorting to the infinite details of botanical descriptions, keys, or measurements.

Enumeration of objects of line selection.—Since our line of work in the F_4 generation narrowed down to three hybrids only, it may not be amiss to repeat here by enumerating the specific characters and qualities we were selecting and others that were noted in the results as of value, and in our discussion of results to mention the specific lines or strains isolated for a definite purpose. However, it should be mentioned in passing that a certain selected line may have one or more of these characters and qualities, as for example, a line with a high breadth index may coincidentally have fallow color in greater proportion than others, or a medium early strain may have leaves with very fine veins and also a high wrapper production index, etc. In other words, a selected line may show more than one of the definite objects in breeding and the more the strain has them, the nearer it approaches the *ideal* wrapper tobacco plant, provided that these characters are not diametrically opposed, as medium early and late characters. Our selection were for the following:

A. Wrapper yield
B. Mosaic resistance
C. Uniformity of color
D. High breadth index
E. High leaf number
F. High wrapper production index
G. Fineness of veins
H. Fallow (aceitunado) color
I. Elasticity and suppleness
J. Medium early wrapper strains
K. Late wrapper strains
L. Dual-purpose strains
M. Trueness to type

Besides these definite objects, the breeder is always on the lookout for novelties or chance mutants, the sudden appearance of which will give him great surprise and add zest to his labors. And he has a great chance of obtaining mutant in hybrids (8, 6). Such a giant mutant with very high leaf number suddenly arose at Hacienda San Antonio, Ilagan, Isabela, in the F_8 generation of the pure hybrid line Bx–27 in the season of 1928–29 (1).

Applied plant breeding.—In this work of hybridization followed by line selection and strain tests under review, it will be noted that the writer was more concerned in breeding as an art to produce wrapper and dual-purpose types for the tobacco growers by the isolation of pure and constant strains than in studying laws or corroborating them and other phenomena connected with hybridization. The principles of genetic science and the laws discovered by tobacco breeders of other more advanced tobacco countries served as groundwork and guided us in this task.

Discussion of test row results.—From the data presented in Table 1, the following were found:

In stalk characters there was a considerable variability shown by the different progenies in the test rows. Of importance in wrapper work, the number of leaves one meter from the ground varied for Gx hybrid from 13.4 + 0.191 for Gx F_4–16 to 24.8 + 0.155 for Gx F_4–34; for Hx hybrid from 21.4 + 0.462 for Hx F_4–3 to 28.6 + 0.221 for Hx F_4–1; and for Ix hybrid from 14 + 0.144 for Ix F_4–2 to 23.6 + 0.403 for Ix F_4–12. The wrapper production index ranged in Gx hybrid from 110.4 per cent for Gx F_4–30 to 135 per cent for Gx F_4–55; in Hx hybrid from 126 per cent for Hx F_4–17 to 140 per cent for H_4–3; and in Ix hybrid from 111.6 per cent for Ix F_4–6 to 136.6 per cent for Ix F_4–12.

Likewise, the quantitative characters of the green leaves showed a very marked variation among the test rows. The average number of leaves is of great importance. In this character the variation was 26.9 + 0.389 for GxF_4–30 to 34.3 + 0.507 for GxF_4–34; 29.9 + 0.845 for HxF_4–3 to 42.9 + 0.669 for HxF_4–1; and 24 + 0.196 for HxF_4–14 to 33.7 + 0.428 for IxF_4–12.

The way the leaves are carried on the stem, which can be measured approximately as the angle of insertion of the leaves is a character that has a marked influence on the quality of the wrapper leaves produced. Generally, the smaller the angle of

insertation, the more erect are the leaves, the variation in the angle of insertion were from 41.7 + 0.685 degrees for GxF_4–34 to 59 + 10.685 degrees for GxF_4–43; from 49 + 0.628 degrees for HxF_4–9 to 53.5 + 0.679 degrees for HxF_4–16; and 43.7 + 0.748 degrees for IxF_4–12 to 58.3 + 0.579 for IxF_4–12.

The average mean length and breadth of the middle standard leaves showed great variation among the different strains of the three hybrids.

In leaf breadth index, the variation ranged from 50.9 + 0.558 per cent for GxF_4–34 to 58.6 + 0.875 for GxF_4–16; from 48.9 + 0.444 per cent for HxF_4–1 to 58.7 + 0.652 per cent for HxF_4–17; and from 51.6 + 0.799 per cent for IxF_4–17 to 62.2 + 0.577 per cent for IxF_4–1.

In the botanical characters of the plant and the leaves, while within each hybrid, there were several of these that were the same, yet in some lines or strain there were noticed a few marked differences. These few differing botanical marks, such as position of leaves, shape, surface, color, margin, apex, plant form, form of head, and color of flowers will serve to distinguish one from another as new races. Owing to the close scrutiny for conformity in these respects of the plants within every line studied, it is expected that these different characters will breed true in the purified and constant strains.

In order to get the actual percentage of the plants attacked by the mosaic disease, the whole number of plants in each test row and in the multiplication plot belonging to that row were counted as were also those with mosaic or with suspected mosaic disease. The close proximity of the test rows with one another, allowing vicinity infection, the care of including all the plants with suspected mosaic disease, the abnormally bad weather during their culture and the station land being infested with the disease made the percentage of attacked plants somewhat high in some of the lines. The different test rows showed considerable variation in mosaic susceptibility. The susceptibility and near resistance to this disease of the selected lines could be more accurately taken from larger cultures.

In Table 2 the general test row data, including marked distinguishing characters noticeable at a glance, yield and percentage of wrapper leaves, and fermented leaf characters were combined. In these respects the comparison of the test rows should be made within each of the three hybrids studied. Uniformity of the plants in each of the test was of the first consideration, any row lacking uniformity was considered as still

segregating and was not selected. As to the description of types, reference should be made to the F_2 and F_3 cultures of Gx hybrid and Ix hybrid, respectively. In the selection of the best test rows, adherence to one type only was not thought advisable, because each of the types mentioned had some qualities that recommended themselves. In the development and precocity of the plants, there were variations. There are mentioned for each test row such marked distinguishing characters noticeable at a cursory glance of the plants in the row.

In the yield data, the results of two test rows for each strain were combined and the total number of the plants in the duplicate rows were taken. Because of the only two replications, the number of plants involved was so small to go into separate data for each replication. For the lack of more replications, prevented by the loss of seedlings owing to bad weather, the accuracy of the yield of each strain may suffer, but not the different desirable characters and qualities studied in the strains, a combination of which decided the value of the lines selected for further work. The total average yield per plant in grams and the percentage of wrapper leaves are the limits in this study. In some cases the percentage of wrapper leaves apparently appear high. This is because our classification took into account all the fine and medium fine leaves as wrappers; or all the leaves that fell into the different superior and inferior classes of wrappers in strictly commercial classification. In no case, however, did any strain exceed 69 per cent, the amount generally obtained in pure Sumatra culture in the Cagayan Valley. The range of these percentages lies within the limits between a pure Vizcaya and pure Sumatra large commercial wrapper culture results.(1)

On account of the small quantity of leaves from not more than 200 plants for each strain, the wrapper leaves could not be separated into the many commercial wrapper classes. The results merely serve to compare the lines of each hybrid among themselves. The average yield per plant in grams is given, consisting of both wrapper and filler leaves. In this study, taking the plant as a basis, the result should not be taken as final. The production per hectare basis and the amount of each class of wrappers of the selected lines should be more accurately and reliably taken from larger cultures for several seasons.

As stated elsewhere in this study, the selection of the strains should be carried also in the fermented leaves, which will give

TABLE 2.—*Showing general test row results, including marked distinguishing characteristics of each, yield performance per plant in grams, percentage of wrapper leaves, and principal fermented leaf characters.*

Hybrid name	Line number	Uniformity of plants in the row	Type	Maturity	Development	Precocity	Marked distinguished characteristics
$G\times F^4$	14	Uniform	B	Medium early	Uneven	Partly precocious	Leaves medium broad; erect when young horizontal when mature.
$G\times F^4$	16	do	B	Early	Fair	Precocious	Leaves erect when young, turning horizontal at maturity.
$G\times F^4$	19	do	E	do	do	Partly precocious	Leaves erect, somewhat narrow, light brown.
$G\times F^4$	30	Nonuniform	E	do	Poor	Nonprecocious	Bx-27-like, leaves medium sized.
$G\times F^4$	34	Uniform	A	Medium early	Good	do	Leaves carried at an acute angle, cabbage-like.
$G\times F^4$	43	do	B	Late	Fair	do	Close-set leaves; very wavy. Top leaves with decorative effect.
$G\times F^4$	48	do	E	Medium early	Good	Precocious	Bx-27-like; leaves have swollen appearance, flowers diffused pink.
$G\times F^4$	51	do	D	do	do	do	Leaves erect when young; broad and horizontal at maturity; flowers very light pink.
$G\times F^4$	55	Nonuniform	No special type	Medium early	Fair	Partly precocious	Non-uniformity.
$G\times F^4$	56	Uniform	F	Late	Good	Nonprecocious	Vizcaya-like, leaves horizontal, leaves light green.
$H\times F^4$	1	do	Sumatra type	do	Fair	do	Leaves small, many, close-set like cabbage; erect. Mutant for high leaf number.
$H\times F^4$	3	Nonuniform	do	Medium early	Fair	Partly precocious	Nonuniformity.
$H\times F^4$	9	Uniform	do	do	do	Nonprecocious	Leaves erect and narrow.
$H\times F^4$	16	do	do	Early	do	Fairly precocious	Leaves somewhat narrow; erect.
$H\times F^4$	17	do	do	Medium early	Good	Precocious	Broad leaves.
$I\times F^4$	1	do	A	Late	Excellent	Nonprecocious	Large and broad erect leaves.
$I\times F^4$	2	do	C	Medium early	Good	Precocious	Sumatra-like, tall with small stems.
$I\times F^4$	3	do	D	do	Excellent	do	Vizcaya-like, long narrow leaves.
$I\times F^4$	4	Nonuniform	C	do	Fair	Nonprecocious	Sumatra-like, leaves erect with coarse veins.
$I\times F^4$	5	Uniform	A	Late	Good	Precocious	Broad, fairly erect leaves, dark green.
$I\times F^4$	12	do	C	Early	Fair	do	Young leaves erect, convex. Spoon-like; light pink flowers.

$I \times F^4$	11	...do...	C	...do...	...do...	Precocious	Small leaves; small stem.
$I \times F^4$	16	...do...	A	Medium early	...do...	Nonprecocious	Small, erect, broad leaves.
$I \times F^4$	17	...do...	C	Early	...do...	Precocious	Small close-set leaves; clean looking and smooth.
$I \times F^4$	20	...do...	C	Medium early	Poor	Partly precocious	Small broad leaves; compact flower head.
$I \times F^4$	21	...do...	D	Late	Fair	Nonprecocious	Vizcaya-like, erect leaves when young, turning horizontal at maturity.

TABLE 2.—*Showing general test row results, including marked distinguishing characteristics of each, yield performance per plant in grams, percentage of wrapper leaves, and principal fermented leaf characters*—Continued.

Hybrid name	Line number	Yield of test rows				Total number of plants	Average yield per plant in grams	Fermented leaf characters			Remarks
		Weight in kilos			Per cent wrappers			General color of wrappers	Characters of veins	General textures and suppleness	
		Wrappers	Fillers	Total							
G×F4	14	7.8	11.8	19.6	39.8	200	98	Light brown	Fairly fine, somewhat irregular.	Fine; elastic glossy, smooth leaves.	Selected for further strain test.
G×F4	16	7.2	7.8	15.0	48.0	197	76	Fallow to light brown.	Fine, regular	Fine; fairly elastic and glossy.	
G×F4	19	7.0	4.8	11.8	59.3	198	59.6	Light brown	Coarse	do	
G×F4	30	5.8	6.2	12.0	48.3	198	60.6	do	Fairly fine; irregular	Fairly elastic somewhat glossy.	
G×F4	34	7.6	6.6	14.2	54.6	192	74.0	Homozygous for light brown color.	Fairly fine; regular	Very elastic and glossy.	Do.
G×F4	43	6.4	6.6	13.0	49.2	178	70.0	Light brown	Fine; numerous and irregular.	Elastic	
G×F4	48	4.2	5.2	9.4	4.7	188	50.0	do	Fairly fine; regular	Fine; elastic and glossy	Do.
G×F4	51	6.8	7.0	13.8	49.3	195	70.8	Light brown to fallow.	do	Fine and smooth elastic and glossy.	Do.
G×F4	55	4.8	4.2	9.0	53.3	170	53.0	Light brown to multicolored.	Fairly fine; irregular	Fairly elastic; somewhat glossy.	Do.
G×F4	56	5.2	6.2	11.4	45.6	193	59.0	Brown to fallow	Fairly fine; regular	Fine; elastic somewhat glossy.	Do.
Y×F4	1	7.2	7.4	14.6	49.3	186	78.0	Light brown	Fine; regular	Elastic, glossy	Do.
Y×F4	3	4.6	7.5	12.1	38.0	190	63.7	do	Fairly fine; regular	Fairly elastic	
Y×F4	9	4.4	5.4	9.8	44.9	196	49.0	do	Fairly fine; irregular	do	
Y×F4	16	6.4	5.8	12.2	52.5	198	62.0	Light brown to fallow.	Fine; regular	Elastic and glossy	Do.

Y×F4	17	3.0	7.6	10.6	28.3	194	54.0	Light brown	do	Fairly elastic	Do.
I×F4	1	14.2	12.2	26.4	53.8	198	133.0	do	Fine; regular, placed well apart.	Elastic and glossy	Do.
I×F4	2	8.2	6.0	14.2	57.7	194	73.0	Brown to light brown.	Fairly fine; irregular	Not very elastic	Do.
I×F4	3	10.4	6.8	17.2	60.5	196	88.0	Fallow.	Fine; regular	Fine; elastic, very glossy.	Do.
I×F4	4	6.0	7.4	13.4	44.8	195	69.0	Light brown	Prominent veins, regular.	Fairly fine; fairly elastic and glossy.	
I×F4	5	6.0	8.8	16.8	47.7	197	85.0	Light brown to multicolored.	Coarse	Fairly-fine; fairly elastic.	Do.
I×F4	12	7.4	6.9	14.3	51.0	198	72.0	Light brown to fallow.	Fine; very regular	Fine; elastic and glossy	Do.
I×F4	14	3.3	3.5	6.8	48.2	185	37.0	do	Fine	do	
I×F4	16	5.4	8.4	13.8	39.1	199	69.0	Light brown	Fairly fine; regular	do	
I×F4	17	4.6	4.4	9.0	51.1	182	49.0	do	Prominent veins, irregular.	Fairly fine; not elastic nor glossy.	
I×F4	20	2.8	3.8	6.6	42.4	161	41.0	Light brown to multicolored.	Somewhat coarse regular.	Fairly fine; fairly elastic, not glossy.	
I×F4	21	4.2	4.8	9.0	46.6	155	58.0	do	Fairly fine; regular	Fine; elastic and glossy	Do.

TABLE 3.—*Showing the especially pronounced and other less marked characters and qualities of the hybrid lines selected for further strain tests.*

Hybrid and line number	A. Wrapper yield	B. Near mosaic resistance	C. Uniformity of color in the leaf	D. High breadth index	E. High leaf number	F. High wrapper production index	G. Fineness of veins	H. Fallow color	I. Elasticity and suppleness	J. Medium early wrapper strain	K. Late wrapper strain	L. Dual purpose strain	M. Trueness to type
G×F_4–14	SP		SP	S		S	S		S	S		S	SP
G×F_4–34	SP	SP	SP		SP	SP	S		SP	S			SP
G×F_4–48		S				S	S		SP	S			SP
G×F_4–51	S			S		SP	S	S	S	S			SP
G×F_4–56					S	S	S	S	S		S	SP	SP
H×F_4–1	SP	S			SP	SP	S		SP		S		SP
H×F_4–16		SP	S		SP	SP	S	S	SP				SP
H×F_4–17				SP	SP	S	SP			S			SP
I×F_4–1	SP			SP	SP	S	SP		SP		SP	SP	SP
I×F_4–2	SP			SP		S	S			S			SP
I×F_4–3	SP	SP	SP			SP	SP	SP	SP	S		SP	SP
I×F_4–5	SP	S		SP	S	S					SP	SP	SP
I×F_4–12	SP			S	SP	SP	SP	S	SP				SP
I×F_4–21	S		SP		S	S			SP		SP	SP	SP

NOTE.—The abbreviation SP means selected for pronounced or marked character or quality; S, for character or quality not well marked.

While there are 13 objects of selection enumerated in this table, under J and K, a strain can be either medium or late maturing and under L, a strain may or may not be a dual-purpose strain, so that in the discussion only 11 objects are mentioned that a strain or line may have out of the thirteen.

an industrial value to the selection. This rigid scrutiny of the finished product started with leaves of the initial selections and was continued in the produce of the test rows. A beautiful field appearing test row may disclose some few serious defects in the finished leaves. A patent example of this is the IxF_4–5. This row showed great uniformity, good development, high breadth index, dark green color, and other visible desirable field characters, altogether appearing very promising in the field. The fermented leaves, however, showed prominent veins, and a tendency for multicolored leaves, which are serious wrapper defects. It was, however, retained for further strain test. But with a large quantity of produce in a more propitious season, if it should continue to manifest these objectionable features, it may eventually be eliminated as a wrapper strain.

The selected lines.—Based upon the 11 objects of our selection, the characters, qualities, and adaptation of each strain or line selected appear in Table 3. These are sets of characters and qualities mentioned for each strain. Of the eleven objects, when the test row showed some pronounced character or quality, that particular character or quality was marked as SP in the table. When the character or quality was not especially marked, but present in most of the plants or the leaves it was marked S. In other words, this difference is one of degree with the small number of plants studied. It will be seen in this table that there are lines that have several pronounced characters, and there are also some lines with less of these. Likewise, there are also some lines that had several characters that were not marked, and also other lines with less. To illustrate our meaning: Line GxF_4–34 was especially good in wrapper yield, near mosaic resistance, uniformity of color in the leaf, high leaf number, high wrapper production index, elasticity and suppleness, and came true to type. It had fairly fine veins and was of medium adaptability, but these were not so pronounced as the others. It lacked high breadth index, a defect in a wrapper strain. It could not be considered a dual-purpose strain. The point to be stressed in presenting this table is to show graphically and quickly the number of these two sets of characters and qualities and those also that are absent (marked with a dash) in each of the lines selected. Discounting a few opposing characters, in no case is there a line that has all these qualities. None of our selections, therefore, can be considered the ideal wrapper tobacco strain, but a few are approaching this desideratum. Attention is invited to the following lines in the order named

for each hybrid that have the most desirable qualities: GxF_4–34, GxF_4–14, GxF_4–56; HxF_4–1, HxF_4–16; IxF_4–3, IxF_4–1.

COMPARATIVE STRAIN TESTS OF THE SELECTED F_5 LINES OF THREE HYBRIDS: 1933–34 SEASON

In order to compare the selected strains of each hybrid among themselves, especially as to uniformity, constancy and wrapper yielding ability, to select the lines approaching the ideal wrapper tobacco plant, and to study their adaptability to local conditions and methods of culture and comparative near resistance to disease and pests, tests of 5 selected lines of GxF_5 hybrid, 5 of IxF_5 hybrid, and 3 of HxF_5 hybrid were carried out at the Ilagan Tobacco Station, Isabela, during the 1933–34 season.

Method of procedure.—There were three sets of tests as follows:

I. 5 lines of GxF_5 hybrid; namely, GxF_5–14, –34, –48, –51, and –56.
II. 5 lines of IxF_5 hybrid; namely, IxF_5–11, –2, –3, –5, and –21.
III. 3 lines of HxF_5 hybrid; namely, HxF_5–1, –16, and –17.

The first two series were planted at the same time and in identical manner while the third series consisting of the HxF_5 strains were planted three weeks later.

Seeds (6 grams per bed) of each strain of the first two groups were sown on October 16, 1933, in three standard beds of 12 square meters each. As a precaution against untoward conditions, a bed of each strain was simultaneously sown in the hill lot in order to produce reserve seedlings.

Two seed beds for each strain of the HxF_5 hybrid were sown on November 8, 1933.

Seeds germinated from 6 to 8 days. The parts of the beds with thick growth of seedlings were thinned to about 5 centimeters each way.

Seedlings were transplated 45 days after sowing in a previously well prepared ground. A dose of 10 grams of 14N–16P–12K complete fertilizer was placed in each hole, mixed with fine earth before the seedling was set. The rate of application was 220 kilograms per hectare. The rows were spaced uniformly at 90 centimeter and the plants at 50 centimeters between them. The five strains were planted in succession, allowing one row of 95 meters long each and were replicated 10 times. One-Half of the hectare block was occupied by the GxF_5 hybrid and the other half, by the IxF_5 hybrid. Plantings of these two hybrids were carried out at the same time.

The HxF_5 hybrid strains were planted in small plots, but also replicated 10 times.

All the seed bed and field operations were uniform for all the strains.

Before harvest 10 plants from each row or 100 plants for each strain of the GxF_5 and IxF_5 hybrids and 25 plants each of the HxF_5 hybrid were labelled for measurements or for obtaining other data. All these data are arithmetically averaged, as shown in Table 4. Only a small number were used of each strain of the HxF_5 hybrid, because plants that sustained aphid infestation were not thought advisable to be included as normal plants.

In harvesting the leaves, the 5 regional classes were separately picked.

Two methods of curing the leaves were used.

1. *Wrapper cure.*—All fine and sound leaves from sand, lower and middle standards were cured as wrapper tobacco and totally in the shade.

2. *Filler cure.*—All badly broken, blemished or coarse leaves of the above three regional classes and the upper standards and top leaves were cured in the ordinary manner as filler tobacco. These were sticked and partially wilted and dried in the sun, completing the curing in a standard shed.

These two types of leaves were fermented separately. The wrapper mandala after four turnings reached 54° C. and the filler after several turnings, 50° C.

Both products from each row of 10 replications were separately weighed after fermentation. The product of each row was roughly classified by bundles into fine, medium fine, and thick leaves, as shown in Table 5. After obtaining the weights each of the three classes was combined separately for the commercial classification of the leaves. These data are shown in Table 6.

Interpretation of results.—For obvious reasons the average of the test row results contained in Tables 1 and 2 should not be compared in exact and complete detail with the average results of the strain tests as contained in Tables 4, 5, and 6, except in a relative way. Rather, the strain tests results should serve to compare the strains of each hybrid among themselves and to verify or corroborate every object, as shown graphically in Table 3, which determined their selection. Obviously, strains were selected which satisfied the greater number these objects

TABLE 4.—*Showing the average stalk, green leaf, and plant, characters; and other data of the strain tests.*

Name and strain number	Stalk characters					Green leaf characters										
	Average height	One meter from ground			Average length of internode											
		Average circumference	Average length of internode	Average number of standard leaves		Average total leaves	Average angle of insertion	Average length of leaves	Average breadth of leaves	Average breadth index	Position of leaves (1)	Shape (2)	Surface (3)	Color (4)	Margin (5)
	cm.	*cm.*	*cm.*		*cm.*		*Degrees*	*cm.*	*cm.*	*Per cent*					
G×F5–14	230.9	8.0	6.6	10.8	36.8	30.5	48.2	56.9	32.1	56.4	FE	Ob	Fm	LG	SU
G×F5–34	184.7	8.0	3.4	16.3	3.5	37.1	45.4	59.6	30.4	50.8	E	Ov	SM	LG	U
G×F5–48	225.8	7.7	7.1	11.2	7.2	26.2	48.6	57.1	33.6	58.8	E	Ov	VW	LG	U
G×F5–57	223.0	7.6	5.6	12.0	5.7	27.8	48.7	61.1	34.8	56.9	FE	Ov	Sm	G	U
G×F5–56	213.2	7.8	7.6	10.1	7.6	29.8	50.0	59.7	33.6	56.3	E	Ov	VW	G	U
I ×F5–1	214.4	8.6	7.5	10.5	17.5	30.6	48.0	60.8	38.1	62.6	FE	Ov	SW	G	U
I ×F5–2	251.3	6.7	8.9	9.2	9.0	25.9	44.0	53.6	33.3	62.1	FE–E	Ov	FW	LG	U
I ×F5–3	241.9	7.2	8.2	10.2	8.2	27.9	46.9	62.4	32.0	51.3	H	Ob	SW	LG	U
I ×F5–5	218.2	8.4	7.5	11.1	7.2	28.6	43.0	60.6	36.7	60.5	FE	Ov	W	DG	SU
I ×F5–21	250.5	8.2	8.0	10.0	8.2	27.9	45.8	61.9	34.8	56.4	E–H	Ov	W	G	SU
H×F5–1	202.8	7.6	5.6			33.3		56.6	28.3	50.0	E	Ov	Sm	G	En
H×F5–16	227.7	7.8	6.6			28.0		54.3	27.5	50.6	FE	Ov	Sm	G	SU
H×F5–17	228.5	7.0	7.4			30.0		52.5	29.2	35.8	E	Ov	Sm	G	SU

(1) E = erect, FE = fairly erect, H = horizontal.
(2) Ov = ovate, Ob = oblong, El = elliptic.
(3) Sm = Smooth, W = wavy, SW = slightly wavy, VW = very wavy, Swo = swollen.
(4) G = green, LG = light green, DG = dark green.
(5) En = entire, U = undulate, SU = slightly undulate.

TABLE 4.—*Showing the average stalk, green leaf, and plant, characters; and other data of the strain tests*—Continued.

Name and strain number	Green leaf characters			Plant characters						
	Base (6)	Petiole (7)	Apex (8)	Uniformity (9)	Form of plant (10)	Form of head (11)	Color of flowers (12)	Per cent mosaic	Attack of other diseases	Marked distinguishing characters
G×F5–14	AC	BW	A	U	Lan	Cp	VLP, D	35.7	Not serious	Leaves medium broad, erect when young, horizontal at maturity.
G×F5–34	AC	BW	A	U	Con	Cp	WP	33.8	do	Numerous leaves carried at acute galen, cabbage-like.
G×F5–48	AC	BW	A	U	Lan	Cp	P, D	34.6	do	Bx-27-like, leaves with swollen appearance, flowers diffused pink.
G×F5–57	AC	BW	obt	U	Lan	FCp	WpP	49.8	do	Flowers very high pink. Young leaves erect, broad and horizontal at maturity.
G×F5–56	AC	BW	A	U	Lan	Cp	P, FD	47.8	do	Vizcaya-like, leaves horizontal and light green.
I ×F5–1	AC	BW	A	U	cyl	Cp	P	19.6	do	Large and broad exact leaves.
I ×F5–2	AC	BW	A	U	Lan	Cp	P	13.4	do	Sumatra-like, tall with slender stems.
I ×F5–3	AC	BW	A	U	Lan	SOp	P	13.5	do	Vizcaya-like, long, narrow leaves.
I ×F5–5	AC	BW	obt	U	Con	FOp	P	12.3	do	Broad dark green leaves.
I ×F5–21	AC	BW	obt	U	Lan	Op	LP	13.7	do	Vizcaya-like erect young leaves horizontal at maturity.
H×F5–1	AC	BW	A	U	Lan	Op	P	5.0	do	Sumatra-like resistant to mosaic.
H×F5–16	AC	BW	A	U	Lan	Op	P	7.0	do	Sumatra-like resistant to mosaic.
H×F5–17	AC	BW	A	U	NP	Op	P	7.0	do	Sumatra-like resistant to mosaic.

(6) AC = auriculate clasping.
(7) BW = broadly winged.
(8) A = acute, obt = obtuse.
(9) U = uniform, FU = fairly uniform, NU = non-uniform.
(10) Lan = lanceolate, Con = conical, cyl = cylindrical, NP = nearly pyramidal.
(11) Op = open, Cp = compact, FCp = Fairly compact, SOp = slightly open, Cl = closed.
(12) P = pink, LP = light pink, VLP = very light pink, D = diffused, FD = fairly diffued, WP = whitish pink, WpP = white patched with pink.

TABLE 5.—*Showing the average production per plot, computed yield per hectare, and fermented leaf characters.*

Name and strain number	Rough classification of fermented leaves								
	Fine		Medium fine		Thick		Total yield	Per cent wrappers	Computed yield per hectare
	Kilograms	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*		*Kilograms*
G×F5-14	2,68	20.97	1.440	11.26	8.660	67.77	12.780	32.23	1,418.5
G×F5-34	4.10	26.47	1.280	8.26	10.106	65.27	15.486	34.73	1,618.9
G×F5-48	2.82	22.42	1.310	10.41	8.448	67.17	12.578	32.83	1,387.1
G×F5-51	4.07	30.54	1.365	10.24	7.891	59.22	13.326	40.78	1,479.2
G×F5-56	3.03	18.80	1.000	6.20	12.085	75.00	16.115	25.00	1,788.7
I ×F5-1	3.59	18.59	2.750	13.72	12.976	67.69	19.320	32.31	2,144.5
I ×F5-2	3.30	25.53	2.310	17.79	7.314	56.68	12.930	43.32	1,437.4
I ×F5-3	4.89	24.02	1.115	5.43	14.350	70.55	20.350	29.45	2,258.8
I ×F5-5	4.77	18.85	2.760	10.94	17.770	70.21	25.300	29.79	2,608.3
I ×F5-21	3.38	16.95	2.500	12.53	14.063	70.52	19.940	29.48	2,213.3
H×F5-1							26.600	38.35	1,182.2
H×F5-16							28.300	34.65	1,257.7
H×F5-17							30.000	31.33	1,333.3

TABLE 5.—*Showing the average production per plot, completed yield per hectare, and fermented leaf characters*—Continued.

Name and strain number	Fermented leaf characters and qualities						
	General color of wrappers	Aroma	Color of ash	Burning quality seconds	Character of veins	Feature of leaf	Elasticity
G×F5-14	Light brown	Mild	Whitish gray	13.1	Med. fine	Fine	Very elastic.
G×F5-34	Fallow to light brown	do	Gray	20.0	do	do	Do.
G×F5-48	Light brown	do	do	15.4	do	do	Do.
G×F5-51	do	do	do	16.7	do	Fine-Med. fine	Do.
G×F5-56	do	do	do	8.8	do	Medium fine	Do.
I×F5-1	do	do	do	22.0	Fine	do	Do.
I×F5-2	do	do	do	25.2	Med. fine	Med. fine	Elastic.
I×F5-3	Fallow	do	do	28.0	Fine	Fine	Very elastic.
I×F5-5	Light brown to brown	do	Whitish gray	25.7	Prominent	Med. fine	Do.
I×F5-21	Light brown	do	Gray	33.4	do	do	Elastic.
H×F5-1	do	do	do	22.1	Fine	Fine	Do.
H×F5-16	do	do	do	16.1	do	do	Do.
H×F5-17	do	do	do	24.2	do	do	Do.

TABLE 6.—*Showing the summary of results of marketable classes of wrapper tobacco, the class sizes and the number of leaves per kilo of the strains tested.*

Name and strain number	Fallow (V)		Light brown (LB)		Multicolored (BBL)		Brown (B)		Other wrapper classes	
	Kilograms	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*	*Kilograms*	*Per cent*
G×F5-14	0.46	3.61	0.76	5.94	1.00	7.88	0.50	3.94	1.40	10.94
G×F5-34	0.88	5.69	1.34	8.65	0.97	6.26	0.45	2.90	1.74	11.23
G×F5-48	0.37	2.95	0.74	5.84	1.26	10.01	0.53	4.25	1.23	9.78
G×F5-51	0.83	6.22	0.83	6.22	1.38	10.36	0.42	3.13	1.98	14.85
G×F5-56	0.52	3.22	1.58	3.58	0.98	6.04	0.38	3.36	1.58	9.80
I×F5-1	0.22	1.10	1.08	5.46	2.30	11.80	0.63	3.24	2.11	10.71
I×F5-2	0.44	3.40	1.04	8.02	1.44	11.12	0.83	6.41	1.86	14.36
I×F5-3	2.14	5.59	1.42	5.50	1.58	7.76	0.28	1.37	1.88	9.23
I×F5-5	0.92	3.63	1.58	6.25	1.89	7.45	0.66	2.61	2.48	9.85
I×F5-21	0.38	1.94	1.21	6.01	1.20	6.05	1.09	5.46	2.00	10.02
H×F5-1	2.0	7.52	1.6	6.02	2.2	8.27	0.30	1.13	4.1	15.41
H×F5-16	1.8	6.36	1.3	4.60	2.3	8.13	0.30	1.06	4.1	14.48
H×F5-17	2.2	7.33	0.9	3.00	3.4	8.00	0.90	3.00	10.0	10.00

TABLE 6.—*Showing the summary of results of marketable classes of wrapper tobacco, the class sizes and the number of leaves per kilo of the strains tested*—Continued.

Name and strain number	Total wrappers		Total filiers		Class sizes		Average number of leaves per kilo	
					First (38–46 cm.)	Second (30–38 cm.)	First class	Second class
	Kilograms	*Per cent*	*Kilograms*	*Per cent*	*Per cent*	*Per cent*		
G×F5–14	4.12	32.31	6.66	67.69	72.1	27.9	216	253
G×F5–34	5.38	34.73	10.11	65.27	72.5	27.5	220	269
G×F5–48	4.13	32.83	8.45	67.17	63.6	36.4	216	290
G×F5–51	5.44	40.78	7.89	59.22	78.2	21.8	205	300
G×F5–56	4.06	25.00	12.08	75.00	70.9	17.1	208	264
I×F5–1	6.34	32.31	12.98	62.69	82.91	17.1	179	227
I×F5–2	5.61	43.31	7.34	56.69	49.9	50.1	195	253
I×F5–3	7.00	29.45	14.35	70.55	80.7	19.3	199	277
I×F5–5	7.53	29.79	17.77	70.21	77.6	22.4	172	226
I×F5–21	5.88	29.48	14.06	70.52	75.2	24.8	185	242
H×F5–1	10.20	38.35	16.40	61.65	62.5	37.5	221	260
H×F5–16	9.80	34.63	18.50	65.37	68.4	31.6	209	248
H×F5–17	16.40	31.33	20.60	68.67	69.2	30 8	205	242

of selection and those wanting in these particulars were discarded. In order to check the behavior and performance of each line in certain tests with these specific objects of the selection from the test rows, these characters and qualities should be compared item by item, stating whether they were confirmed, disproved or have shown better results in the strain tests than in the plant-to-the-row tests.

A. Wrapper yield—
Beyond expectation: GxF_5–51, HxF_5–16.
Confirmed by: GxF_5–14, –34; HxF_5–1; IxF_5–1, –2.
Disproved by: IxF_5–3, –5.

B. Near mosaic resistance—
Beyond expectation: IxF_5–5.
Confirmed by: IxF_5–3; HxF_5–1; –16, and –17. GxF_5–34 (the least attacked of the Gx-hybrid strains).

C. Uniformity of color in the leaf—
Confirmed by: GxF_5–14, –34, IxF_5–3.

D. High breadth index—
Beyond expectation: GxF_5–48.
Confirmed by: IxF_5–1, –2, and –5; HxF_5–17.

E. High leaf number—
Confirmed by: GxF_5–34; IxF_5–1; HxF_5–1, –16, –17.

F. High wrapper production index—
Not determined in strain tests.

G. Fineness of veins—
Confirmed by: IxF_5–3; HxF_5–17.
Disproved by: IxF_5–1.

H. Fallow color—
Beyond expectation: GxF_5–34, –51; HxF_5–1, –16, –17.
Confirmed by: IxF_5–3.

I. Elasticity and suppleness—
Confirmed by all strains.

J. and K. Medium and late wrapper strains were not determined in the strain tests.

L. Dual-purposes strains—
Confirmed by GxF_5–56; IxF_5–1, –3, –5, and –21.

M. Trueness to type or constancy—
Confirmed by all strains under test.

With the data above and taking the sum total of the predominating characteristics and qualities shown by the different strains, the relative value for wrapper of the strains of each hybrid may be stated in the order named as follows:

GxF_5–34, –14, –51, –48, and –56.
HxF_5–1, –16, –17.
IxF_5–3, –1, –2, –5, and –21.

SUMMARY

General.—1. This study presents the efforts of six years to improve the best native cigar filler variety, the Vizcaya, by hybridization with Sumatra strains and constant hybrids thereof as male parents, followed by line selection and strain tests in the direction of producing wrapper and dual-purpose strains.

2. The technique of tobacco hybridization is very simple. The subsequent isolation and purification of desirable lines is the more difficult, requiring time, skill, and continuity of efforts.

3. Out of the six different hybrids, three, with the Vizcaya as female parent, were found promising.

4. There were definite principal types; 6 in the Gx hybrid, 3 in the Hx hybrid, and 5 in the Ix hybrid, found in the F_2 and the succeeding generation.

5. In plot cultures of four of the segregating hybrids in the F_3 generation, the Gx hybrid was found to be the most productive. It was found that Hx hybrid was the most nearly resistant to mosaic disease.

6. As far as the writer is aware, this is the only work in this country of native—Sumatra hybrids that have been undertaken continuously for six years by the same worker with the definite object of producing distinct medium-sized Philippine wrapper leaves. This is an attempt to help solve the wrapper problem with the peculiar climatic and soil conditions and method of culture in the Cagayan Valley.

Plant-to-the-row test.—1. There were originally 88 selection of hybrids sown in seed beds during the F_4 generation. Frequent storms reduced this to 10 selections of the Gx hybrids, 5 of the Hx hybrid, and 11 of the Ix hybrid, which were run in duplicate test rows of 100 plants each.

2. There were considerable variations in types, character, quality, and some botanical morphologic characters in the test rows, as shown by complete data presented in Tables 1 and 2.

3. Attention is invited to the carrying of the selection in the fermented leaf of all the strains studied and the new data tentatively called "wrapper production index."

4. Five lines of the Gx hybrid consisting of 5 definite types, 3 lines of the Hx hybrid of only one type, and 6 lines of the Ix hybrid of 3 types (2 lines of each type), were selected for further strain tests. How these different selected lines responded to the eleven objects of selection are graphically shown in Table 3.

5. Of the selected lines, the following in the order named have the most desirable characters and qualities: GxF_4–34, –14, –56; HxF_4–1 (a mutant for high leaf number), –16; IxF_4–3, –1.

Strain tests.—1. All the strains tested are now constant and show remarkable uniformity of type within the strains. The strains differ in botanical, morphological characters and behavior and they should now be considered as distinct races or varieties.

2. They differ in their individual susceptibility to pests and diseases. Within the hybrid, the most nearly resistant to the mosaic disease are the Hx hybrid lines, especially HxF_5–1, followed by the IxF_5 hybrid strains.

3. From each hybrid, the best results, confirming the findings in the previous tests, in wrapper qualities were shown by GxF_5 –34; –14; HxF_5–1; –16; IxF_5–3, and –1. These can be distributed to planters for the commercial production of wrapper tobacco.

4. The culture to which these strains were subjected was a compromise between the elaborate wrapper, and filler, cultures, and it is to be expected that under the elaborate culture, these strains will give a better account of themselves. The strains showed high adaptability to Ilagan, Isabela, conditions.

5. Depending upon the method of culture, these six best strains of the three hybrids can be expected to produce a preponderance of a wrapper crop or for both wrapper and filler crops.

6. The original objects in making these crosses have been attained in some of these strains.

LITERATURE CITED

1. GUTIERREZ, M. E. Some considerations in breeding wrapper tobacco in the Philippines. Read at the Bureau of Plant Industry Seminar, Aug., 1934.
2. PRIEGO Y JARAMILLO, J. M. Memoria relativa. *Bolitin oficial agrícola de Filipinas.* 3 (Nov. 3, 1896) 11.
3. GUTIERREZ, M. E. Progress report of five new hybrid varieties of tobacco. *Philippine Agricultural Review,* p. 253 et seq. 17 (1924) No. 4.
4. HAYS, H. K. and GARBER, R. L. Breeding crop plants, p. 164.
5. De VRIES, HUGO. Plant breeding, p. 187 et seq.
6. TOLLENAR, D. and MIDDELBURG, Ir. H. A. Grondalagen en resultaten der Tegenwoordige veredeling bij de Verstenlandsche Tabak. Proefstation voor Verstenlandsche Tabac. Modedeeling No. 63 (193(?)).
7. MENDIOLA, N. B. Manual of plant breeding for the Tropics.

ILLUSTRATIONS

PLATE 1

FIG. 1. Field of Vizcaya plants, the female parent used in four hybrids. This is the native variety chosen for developing a native wrapper type.

2. Baker Sumatra plant. Baker Sumatra is the best wrapper Sumatra strain in the Philippines.

PLATE 2

FIG. 1. The row at the right shows the Ax–11 in line selection at Pikit, Cotabato, 1923–1924 season. The male parent of Vizcaya × Ax–11 or Fx hybrid.

2. Plant of the Bx–27, a pure line of the hybrid Florida Sumatra and Baker Sumatra. The male parent of the Vizcaya × Bx–27 or Gx hybrid.

PLATE 3

FIG. 1. The row at the left shows the Bx–27 while in line selection work at Pikit, Cotabato, 1923–24 season.

2. The method of bagging tobacco flowers for crossing, 1928–29 season. The bag is made of cheesecloth with 2 wire rings to have a cylindrical form, permitting sunlight to the flowers but not the access of insects.

PLATE 4

FIG. 1. Type A, a good wrapper type.

2. Type D, a good dual-purpose type, of the Gx F_2 hybrid.

3. The Gx F_3 hybrid in plot test.

PLATE 5

FIG. 1. The Hx F_3 hybrid in plot test, 1931–32 season.

2. The Ix F_3 hybrid in plot test, 1931–32 season.

3. The Kx F_3 hybrid in plot test, 1931–32 season.

PLATE 6

FIG. 1. Plant-to-the-row test with Gx F_4 hybrid. Note the variability shown by the different rows. Note also the uniformity of plants shown by some of the test rows, especially Rows 14, 34, 48, 51, and 56.

PLATE 7

FIG. 1. Plant-to-the-row test with Hx F_4 hybrid. Note the variability shown by the different rows. Note uniformity of plants in the rows as to height and flowering. Row 1 had not yet flowered when the photograph was taken.

PLATE 7—(Continued)

FIG. 2. Plant-to-the-row test with Ix F_4 hybrid. Note the variability shown by the test rows. Note also uniformity of plants shown by certain rows. Rows 1 and 5 had not yet flowered when the photograph was taken. Note the difference in size and width of the leaves of the plants of different rows.

PLATE 8

FIG. 1. Representative leaves of different strains of the Gx F_4 hybrid. Note difference in shape, size, width, venation, and apex.

2. Representative leaves of different strains of Ix F_4 hybrid. Note difference in shape, size, width, venation, and apex.

PLATE 9

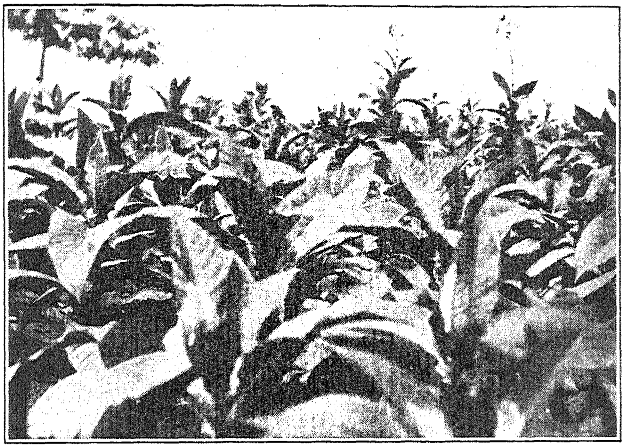
FIG. 1. The GxF_4–34, a line that was selected for its many outstanding qualities and characters with leaves curing a uniformly rich light brown color. It does not have a high breadth index, its only defect. It is less attacked by the mosaic disease than other Gx hybrid selected strains.

2. The IxF_4–1, a line that was especially selected for the high breadth index of its leaves (62.2 ÷ 0.577%) and also the highest yielding strain. It bred true to type as shown by the great uniformity of its progeny. It has a high leaf number, high wrapper production index, with fine veins and good elasticity and suppleness. Being a late strain with large broad leaves, it can also be considered a dual-purpose strain.

PLATE 10

FIG. 1. The IxF_4–3, a line that produced the largest proportion of light fallow (aceitunado claro) colored leaves among all the strains under study, a character inherited from the American Sumatra, its male parent. It has the appearance of the Vizcaya, its female parent, but is superior to it in wrapper yield, near mosaic resistence, uniformity of color in the leaf, high wrapper production index, fineness of veins, elasticity and suppleness. It may be also considered a dual-purpose strain.

2. The IxF_4–5, the line that showed a beautiful field appearance, but was somewhat remiss in the fermented leaf results, proving the contention that selection must await the fermented leaf results. It has, however, high wrapper yield, high breadth index, bred true to type, and of late adaptability. An excellent dual-purpose strain with broader leaves than the Vizcaya, its female parent.



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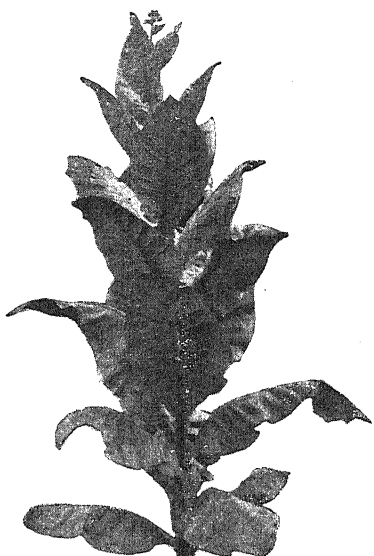
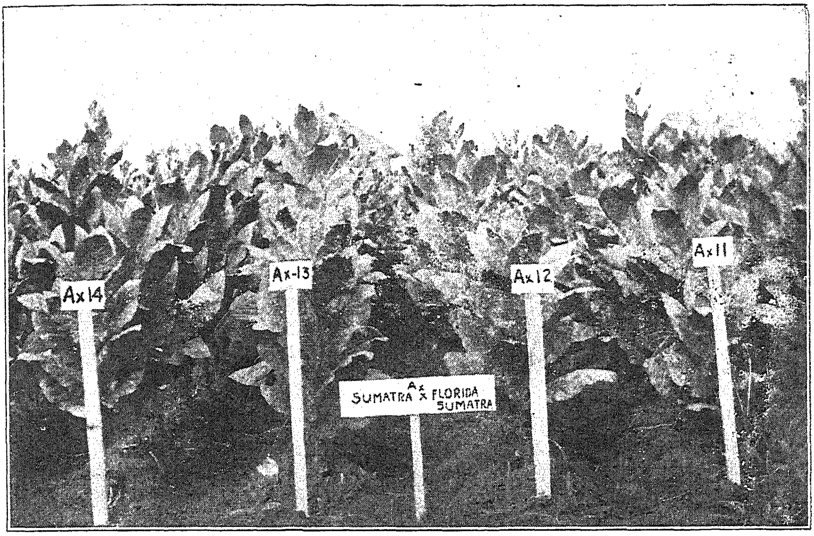


2

PLATE 1.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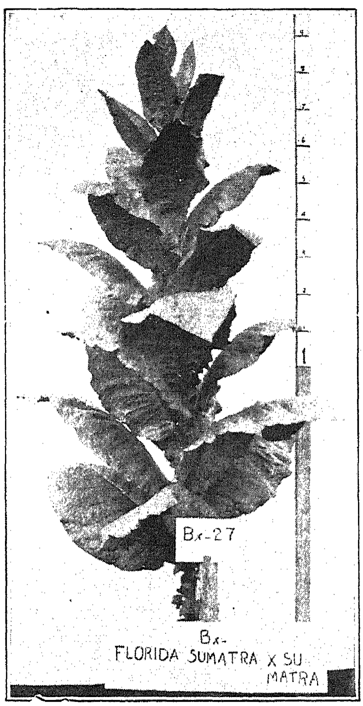
Ax-13
Ax12
Ax11
Ax
SUMATRA x FLORIDA SUMATRA

1


Bx-27
Bx-
FLORIDA SUMATRA X SU MATRA

2

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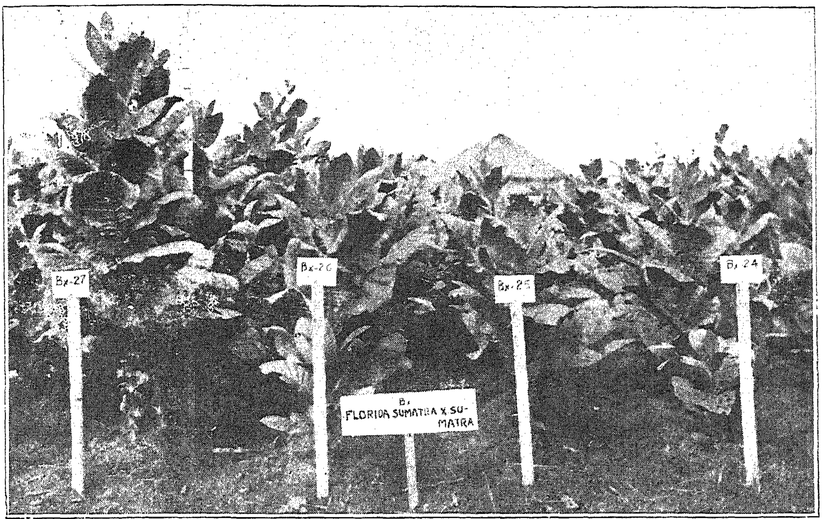

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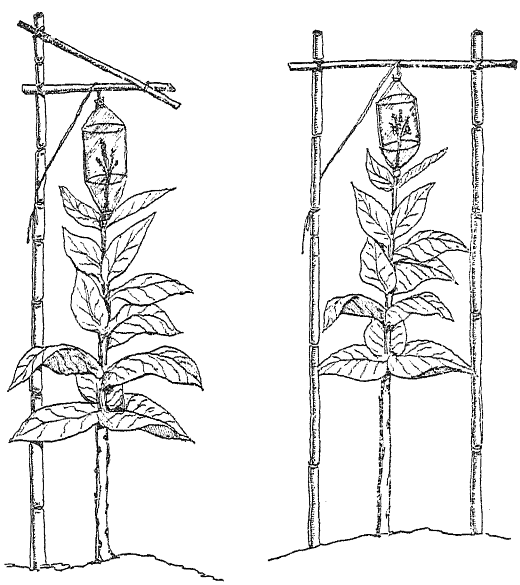

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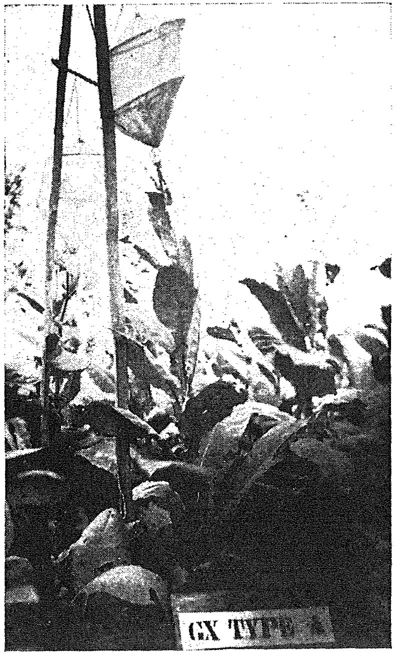

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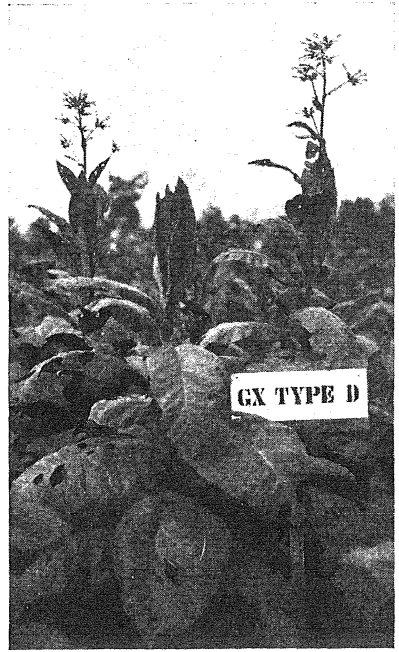


2

3

PLATE 4.

1

2

3

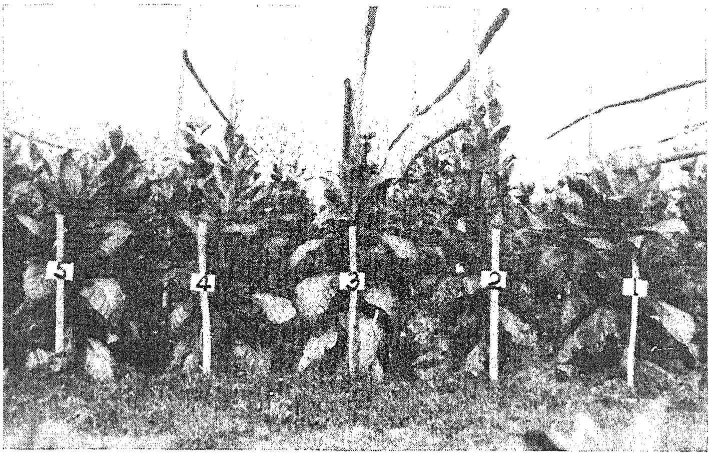
PLATE 5.

1

2

3

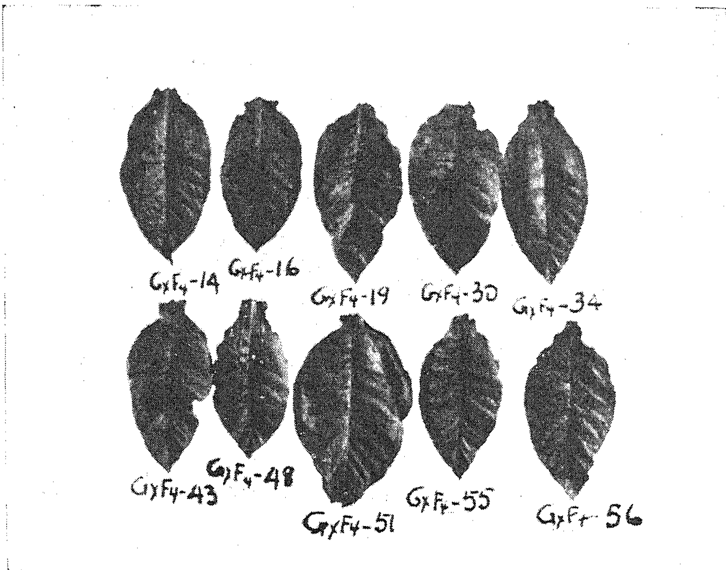
PLATE 6.



1

2

PLATE 7.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GxF4-16
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GxF4-30
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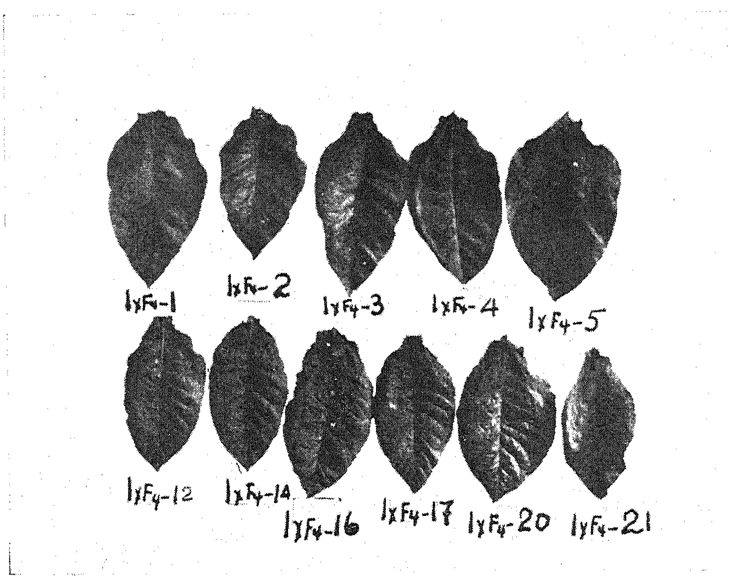
GxF4-55
GxF4-56

1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IxF4-2
IxF4-3
IxF4-4
IxF4-5
IxF4-12
IxF4-14
IxF4-16
IxF4-17
IxF4-20
IxF4-21

2

PLATE 8.

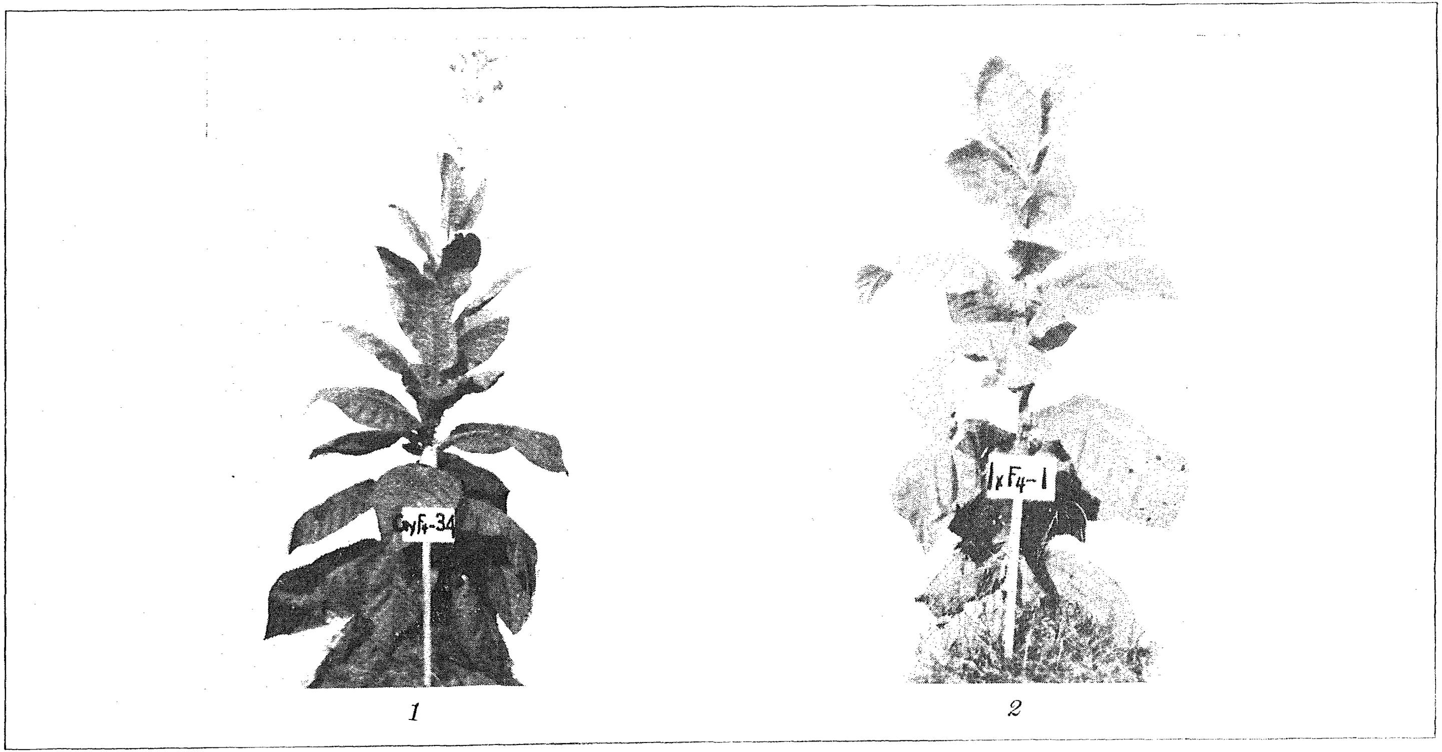
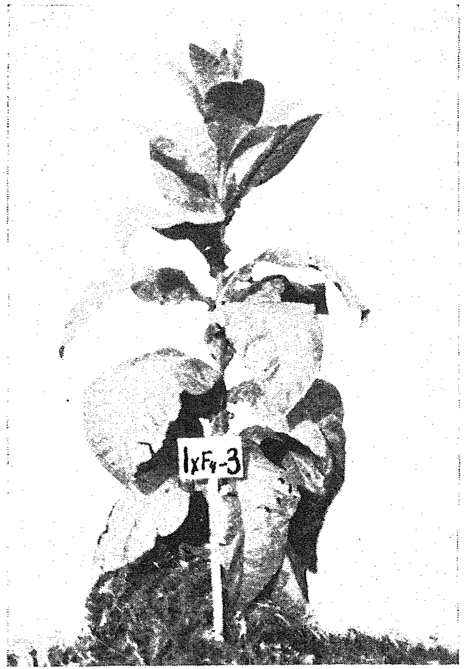


PLATE 9.



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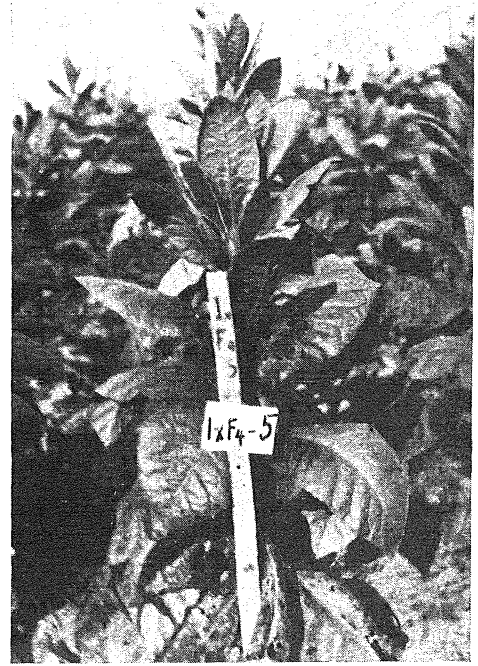


2

PLATE 10.

A FIELD STUDY ON THE CITRUS GREEN BUG *RHYNCHOCORIS SERRATUS* DONOVAN

By CATALINO E. GARCIA
Assistant Agronomist, Bureau of Plant Industry

FOUR PLATES

This insect, which belongs to the Family *Pentatomidae,* subfamily *Pentatominae,* Order *Hemiptera,* has been observed rather harmful to citrus fruits in the Philippines, causing them to fall off. In the orchard of Mr. Jose Alvarez, at Mailag, Bukidnon, it caused a loss in 1931 of from 30 to 40 per cent of the crop of sweet orange (cajel). At Novaliches, Caloocan, the insect caused a loss in 1933 of from 15 to 30 per cent of the mandarin and calamondin crops. The following varieties were found attacked by the bug at the Citrus Station at Tanauan, Batangas, the damage varying from 8 to 26 per cent of the crops:

1. Ruby orange
2. Majorca orange
3. Dougat orange
4. Du Roi orange
5. Pineapple orange
6. Batangas orange
7. Batangas mandarin

This insect was the subject of complaint to the Bureau of Agriculture, and later to the Bureau of Plant Industry, from growers in various parts of the Islands. In view of its seriousness, it was decided that a study be made of the life history, habits and the means of controlling the insect. The data presented in this paper were obtained at Novaliches, Caloocan, Rizal, in 1933 and 1934.

GEOGRAPHICAL DISTRIBUTION

The citrus green bug is apparently widely distributed in the Philippines. Besides the personal field observations of the writer, as already given, Merino (1928) reported it as having caused in that year the falling off of most of the fruits of oranges in an orchard at Sison, Pangasinan. According to De Leon (1932), this insect is commonly found in Luzon, Visayas, and

Mindanao and attacks the fruits of calamondin, mandarin, and sweet ranges, causing them to fall off.

In other countries, Distant (1902) reported that the insect is found at Malabar, British India, Malay Peninsula, Java, Sumatra, and Borneo.

The citrus green-bug causes the same type of injury as that by *Rhynchocoris humeralis* Thunb., which is found in Assam, as reported by McSwiney (1919), Mitra and Khonwir (1928) and Gupta (1928). According to Hoffmann (1928) *Rhynchocoris humeralis* is also found in China and is a pest of oranges there.

MANNER OF FEEDING AND NATURE OF INJURY

The manner of feeding of adult *Rhynchocoris serratus* was studied in cages in the laboratory at Novaliches. Repeated observations showed that this insect, without being disturbed, stayed on the fruits usually from 6 a. m. to 8 p. m. It was observed that while feeding, the insect remained motionless on the fruit holding its labium at right angle and then directing the mandibles into the fruit. After a few minutes the labium was placed in its ordinary position leaving the mandibles and maxillae in the tissues of the fruit. While the mandibles and maxillae were inside the fruit the insect moved its head up and down. This motion, perhaps, was for the purpose of locating the locules of the fruit and to place the mouth parts in position for sucking. The puncture is about one-half of a millimeter in diameter.

Injured fruits exhibited a light yellow color on the rind around the puncture. From two to five days thereafter, the fruits fell off. Most of the fruits attacked by the bug were about one to five centimeters in diameter. The mature fruits were found seldom attacked by this insect.

LIFE HISTORY AND DESCRIPTIONS

METHODS OF STUDY

Eight nymphs in the fifth instar were captured from the field and these were reared in a battery jar with fruits of calamondin and mandarin. The dates of their changing to the adult stage were recorded. Mating was then observed, and each pair in copula was placed separately in a battery jar (16 cm. diameter by 20 cm. high) and this covered with cheese cloth. The insects were kept supplied with fruits and fresh leaves of calamondin, mandarin, and cabuyao. Every day the food materials thus furnished were examined for eggs and the old ones

changed every three days. Each mass of eggs was kept in a separate container and labeled or given the number of its corresponding mother.

The newly emerged nymphs were reared on trees in celluloid cylinders 35 centimeters long and 15 centimeters in diameter (Plate 4, fig. 1). Both ends of each cylinder were fitted with cheesecloth. Fruits and leaves of calamondin and mandarin were enclosed in each cylinder and five nymphs were placed in each cage with them. The cylinder and the nymphs were transferred to fresh fruits when the old ones dropped.

EGGS

The eggs are laid on the upper surface of the leaf in groups of from 3 to 14. Each individual egg measures about 2 millimeters and is somewhat spherical, creamy white and smooth. Immediately before hatching it turns light yellow. The chorion is white and transparent.

NYMPH

There are five instars as follows, with their respective descriptions:

First instar.—Newly emerged nymph, about 3.5 millimeters long and 2.9 millimeters wide. Color mostly light yellow to orange.

Head black, over one-third the length of the whole body. Antennae black, five-segmented, about three times as long as head. Eyes somewhat hemispherical, reddish brown, set laterally at base of head. Labium concolorous with head, over two-thirds as long as body, four-segmented, all segments unequal in length.

Thorax black, about one-third as long as body; prothorax about twice the length of mesothorax; metathorax less than one-half as long as mesothorax.

Abdomen over one-third as long as body. Color orange. Black spots are present along marginal and mesal regions.

Second instar.—About 6 millimeters long and 4 millimeters wide just after first molting. Color mostly light orange.

Head, black and white at margin, about one-fourth the length of the body. Antennae five-segmented, about five times as long as head, with the last segment white and black at tip. Labium, extending to about middle of sixth abdominal segment; four segmented; all segments unequal in length.

Thorax black with white anterior margin. Length, about one-third that of body; prothorax about one-half total length

of thorax; mesothorax about one-half as long as prothorax; metathorax about one-half as long as mesothorax.

Abdomen, about one-third as long as body; color and markings as in first instar.

Third instar.—About 8 millimeters long and 6 millimeters wide just after second molting. Color light orange. Characters of head and the rest of the body similar to those of second instar.

Fourth instar.—About 12 millimeters long and 7.0 millimeters wide just after the third molting. Color mostly orange.

Head black with white anterior margin. Other characters similar to those preceding instar.

Fifth instar.—About 18 millimeters long and 10 millimeters wide just after the fourth molting. Color mostly orange.

Head, white along the margin and black at median. Labium about four times the length of head, four-segmented; extends to middle of sixth abdominal segment.

Thorax, over one-half whole body in length, prothorax, over one-third total length of thorax, mesothorax about five times as long as prothorax, metathorax about two times as long as mesothorax. Scutellum somewhat triangular, over nine times as long as body. Wing pads concolorous with body, extending to the third abdominal segment; length over four times that of body.

Abdomen, about one-half of body in length. Color, orange. Spots along margin somewhat crescent in shape and spots on mesal region as in the first to fourth instars.

ADULTS

Male.—Length, about 20 millimeters. Color, olive-green. Body thickly punctate.

Head subconical, about one-fifth total length of body. Antennae about three-fourths of body in length; five-segmented; all segments unequal in length. Labium, about three-fourths of body in length, extends to end of fifth abdominal segment.

Prothorax, about one-fourth whole body in length. Scutellum concolorous with body, somewhat triangular, about one and six-tenths of prothorax in length. Hemelytra about four-tenths longer than abdomen in length. Corium thick, finely punctate; membrane thin and membranous.

Abdomen, about one-half as long as body, length subequal to greatest width. Tergites, olive-green. Sternites, blue with olive-green margin. Spine, five at each margin. Genital seg-

ment somewhat rectangular, about one-half as long as the preceding segment. Spine none at both sides.

Female.—Length, about 24 millimeters. Caudal segment slightly broader than length. Spine present at both sides of abdominal segment preceding the anal segment. Other characters similar to male.

Rynchocoris serratus Don. (Cimex) was described in the Fauna of British India by Distant (1902) as follows:

> Olive-green or ochraceous; differing principally from the preceding species (*R. humeralis* Thunb.) by the lateral angles of the pronotum, which are slender, acutely pointed, their apices very slightly recurved, black, or very coarsely blacky punctate; lateral margins of the lateral lobe of head profoundly black; connexivum unspotted, the segmental angles only black.
>
> Length, 20–24; breadth between pronotal angles 16 to 18 millimeters.

OBSERVATIONS ON ADULTS

Under field conditions, the adults were observed to begin feeding on the fruits at about six o'clock in the morning. At noon time, when the day was hot, they were found to hide among the leaves. They resumed feeding in the afternoon, and without being disturbed, they stayed on the fruits until late in the evening.

COPULATION

Copulation was observed in the laboratory to take place in the morning. The sexes were observed to remain in copula from 4 to 48 hours during which they also fed. No pair was observed to go into copula in the afternoon. Only three copulations were observed during the lifetime of a couple. Table 1 gives a record of copulations of six pairs of adults under confinement in battery jars.

TABLE 1.—*Records of copulation*

Culture number	Date of emergence of female	Date of first copulation	Age of female	Date of last copulation	Intervals of first and last copulation
			Days		*Days*
1	21–VI–34	2–VII–34	12	30–VIII–34	59
4	25–VI–34	5–VII–34	10	21–IX–34	78
5	29–VI–34	8–VII–34	9	12–VIII–34	35
6	30–VI–34	24–VII–34	24	escaped	----------
37	23–VIII–34	4–IX–34	12	3–X–34	29
38	27–VIII–34	4–IX–34	8	20–IX–34	16

Average .... 12.5 days
Maximum .... 24 days
Minimum .... 8 days

From the preceding table, the first copulation took place when the females were 8 to 24 days old (that is, 8 to 24 days after emergence) with an average age of 12.5 days. The interval between the first copulation and last copulation is from 16 to 78, the average being 43.5 days.

OVIPOSITION

Oviposition was found to take place in the afternoon. When the female finds a suitable place it remains motionless, placing the end of its abdomen close to the leaf and after a few minutes an egg is laid. After an egg is laid, it rests for a few minutes before laying another egg. Table 2 gives the ages of some female insects before they laid their first eggs and the time of last egg-laying.

TABLE 2.—*Age of female at first and last egg-laying*

Culture number	Date of emergence	First oviposition		Last oviposition	
		Date	Days	Date	Days
1	21-VI-34	26-VII-34	35	4-X-34	105
4	25-VI-34	16-VII-34	21	26-IX-34	93
5	29-VI-34	19-VII-34	20	3-IX-34	66
6	30-VI-34	28-VII-34	28	escaped	-------
37	23-VIII-34	7-IX-34	15	5-X-34	43
38	27-VIII-34	6-IX-34	10	26-IX-34	30
38-a	23-VIII-34	18-IX-34	2[illegible]	25-IX-34	33

Average age .... 22 days
Maximum age .... 35 days
Minimum age .... 10 days

From the preceding records, the ages of the female, when they commenced laying were from 10 to 35 days, the average being 22 days. The ages of the insects when they laid their last eggs were from 30 to 105 days, or an average of 61.6 days.

DAILY AND TOTAL RATE OF OVIPOSITION

Five couples were observed in the laboratory for egg-laying record. Table 3 gives the daily and total number of eggs laid by five females, each having been confined with a male.

As may be seen from the above table, the number of eggs laid by each individual female per day ranged from 3 to 14, or an average of 12.5 eggs per day. The total number of eggs laid were from 81 to 253, the average being 151.8 eggs for each female. These eggs were laid at intervals of 2 to 9 days.

TABLE 3.—*Daily records of eggs laid*

Number of oviposition	Culture No.				
	1	4	5	9	12
	Eggs	*Eggs*	*Eggs*	*Eggs*	*Eggs*
1	14	14	13	7	11
2	14	14	13	7	14
3	14	14	14	11	14
4	14	13	14	14	14
5	14	14	14	14	14
6	13	14	13	14	14
7	14	14	0	13	14
8	13	14	0	14	5
9	8	14	0	14	10
10	14	0		13	14
11	14	0		12	0
12	14	0		13	0
13	14			12	0
14	14			4	
15	14			14	
16	11			0	
17	11			0	
18	8			0	
19	3				
20	10				
21	8				

Average 12.5
Maximum 14
Minimum 3

TABLE 4.—*Incubation period*

Culture number	Date of egg laid	Date of hatching	Length of incubation period
			Days
2	22–VI–34	27–VI–34	5
7	28–VI–34	4–VII–34	6
9	12–VII–34	17–VII–34	5
10	19–VII–34	24–VII–34	5
11	22–VII–34	29–VII–34	7
12	24–VII–34	29–VII–34	5
13	31–VII–34	5–VII–34	5
14	6–VIII–34	13–VIII–34	7
15	10–VIII–34	16–VIII–34	6
21	12–VIII–34	18–VIII–34	6
24	16–VIII–34	22–VIII–34	6

Average .... 5.72 days
Maximum 7
Minimum 5

TABLE 5.—*Duration of instar and total number of days of nymphal stage.*

	Culture No. 31		Culture No. 32		Culture No. 33		Culture No. 34	
	Date	Average number of days between moltings	Date	Average number of days between moltings	Date	Average number of days between moltings	Date	Average number of days between moltings
		Days		*Days*		*Days*		*Days*
Egg hatched	21–V–34		23–V–34		1–VI–34		27–VI–34	
First molt	26–V–34	5	27–V–34	4	6–VI–34	5	2–VII–34	5
Second molt	2–VI–34	7	2–VI–34	6	12–VI–34	6	7–VII–34	5
Third molt	7–VI–34	5	10–VI–34	8	18–VI–34	6	14–VII–34	7
Fourth molt	12–VI–34	5	15–VI–34	5	23–VI–34	5	21–VII–34	7
Fifth molt	21–VI–34	9	25–VI–34	10	3–VII–34	10	30–VII–34	9
Nymphal stage		31		33		32		33
	Culture No. 35		**Culture No. 36**		**Culture No. 37**		**Culture No. 38**	
Egg hatched	4–VII–34		17–VII–34		24–VII–34		29–VII–34	
First molt	8–VII–34	4	21–VII–34	4	27–VII–34	3	2–VIII–34	4
Second molt	13–VII–34	5	26–VII–34	5	4–VIII–34	8	7–VIII–34	5
Third molt	20–VII–34	7	2–VIII–34	7	11–VIII–34	7	13–VIII–34	6
Fourth molt	27–VII–34	7	11–VIII–34	9	16–VIII–34	5	21–VIII–34	8
Fifth molt	6–VIII–34	10	21–VIII–34	10	23–VIII–34	7	31–VIII–34	10
Nymphal stage		33		35		30		33

	Culture No. 41		Culture No. 42		Culture No. 43		Culture No. 44	
Egg hatched	3-VIII-34		5-VIII-34		5-VIII-34		13-VIII-34	
First molt	8-VIII-34	5	9-VIII-34	4	9-VIII-34	4	17-VIII-34	4
Second molt	15-VIII-34	7	15-VIII-34	6	15-VIII-34	6	23-VIII-34	6
Third molt	21-VIII-34	6	21-VIII-34	6	22-VIII-34	7	29-VIII-34	6
Fourth molt	27-VIII-34	6	27-VIII-34	6	S		3-IX-34	5
Fifth molt	6-IX-34	10	5-IX-34	9			13-IX-34	10
Nymphal stage		34		31				31
	Culture No. 45		Culture No. 46		Culture No. 47		Culture No. 48	
Egg hatched	15-VIII-34		16-VIII-34		16-VIII-34		18-VIII-34	
First molt	20-VIII-34	5	21-VIII-34	5	21-VIII-3	5	22-VIII-34	4
Second molt	26-VIII-34	6	28-VIII-34	7	26-VIII-34	5	27-VIII-34	5
Third molt	31-VIII-34	5	2-IX-34	5	31-VIII-34	5	3-IX-34	7
Fourth molt	7-IX-34	7	10-IX-34	8	8-IX-34	8	9-IX-34	6
Fifth molt	18-IX-34	11	20-IX-34	10	19-IX-34	11	20-IX-34	11
Nymphal stage		34		35		34		33
	Culture No. 49		Culture No. 50		Culture No. 51		Culture No. 52	
Egg hatched	17-VIII-34		21-VIII-34		22-VIII-34		28-VIII-34	
First molt	22-VIII-34	5	26-VIII-34	5	27-VIII-34	5	2-IX-34	5
Second molt	27-VIII-34	5	31-VIII-34	5	2-IX-34	6	8-IX-34	6
Third molt	2-IX-34	6	5-IX-34	5	7-IX-34	5	13-IX-34	5
Fourth molt	10-IX-34	8	10-IX-34	5	13-IX-34	6	19-IX-34	6
Fifth molt	20-IX-34	10	20-IX-34	10	23-IX-34	10	28-IX-34	9
Nymphal stage		34		30		32		31

INCUBATION PERIOD

Eggs in groups collected from the different cultures in the laboratory were used for determining the period of incubation. Table 4 gives the incubation period of the eggs of *R. serratus* under laboratory conditions.

From the table above, it will be seen that the incubation period of the eggs during the months of June, July, and August was from 5 to 7 days, with an average of 5.72 days.

DURATION OF NYMPHAL STAGE

The nymph passess through five instars. Table 5 shows the records of 18 sets of nymphs under observation.

From Table 5, it may be seen that the first instar lasted from 3 to 5 days; the second, 5 to 7; the third, 5 to 8; the fourth, 5 to 9; and fifth, 7 to 11 days, the average being 4.35 days for the first instar; 5.8 for the second, 6.05 for the third, 6.42 for the fourth, and 9.7 days for the fifth instar.

NYMPHAL HABITS

The first instar nymphs are gregarious and in the field were observed to stay chiefly on the leaves. At this stage they were found to subsist upon the sap of the leaves. After the first molt they migrated to the branches and searched for the fruits to feed. Feeding on the fruits took place between 7 to 9 o'clock in the morning. When they were not feeding they stayed among the leaves and resumed feeding in the afternoon.

SEASON OF ABUNDANCE

In 1933 and 1934, at Novaliches, Caloocan, Rizal, it was observed that the insect in all stages was abundant during the months of May to August; that is, the abundance coincided with the fruiting season. During these months considerable numbers of fruits fell due to the attack. The pest was found scarce during September, October, and November, as most of the fruits were maturing and unsuitable for the food of the bug.

FOOD PLANTS

Rhynchocoris serratus was found to confine its attack to the citrus family. It was noted that the cabuyao (Citrus hystrix), calamondin (*Citrus mitis* Blanco), lemon (*Citrus limonia* Osbeck), limes (*Citrus aurantifolia* Swingle) and cajel (*Citrus sinensis* Osbeck) are favorite host plants of this insect. The pummelo and king mandarin were observed resistant to the at-

tack. The reason, perhaps, is that the pummelos have thick rinds, and that the king mandarin has a tough and rough rind, which makes it difficult for the insect to suck the juice.

NATURAL ENEMIES

Two kinds of predators of this pest were observed in the field, one of them being a species of mantid, *Hierodula patellifera* Serv.[1] Another predator is the big red ant, *Oecophylla smaragdina,* which feeds on the nymph. It was found that with the presence of this ant in the tree, no bugs alighted on the fruits. McSwiney in Assam reported that *O. smaragdina* preyed upon *Rynchocoris* sp. In China, Hoffmann mentioned that the nymphs of *R. humeralis* are destroyed by a certain mantid. He also stated that the introduction of this predator in the orchard may help to reduce the pest. De Leon in his report, writing on citrus propagation in the Philippines, casually mentioned that the egg of *R. serratus* are parasitized by a certain small wasp. However, the writer has not reared any from eggs collected from the field at Novaliches during the abundance of this pest in June and July, 1934. Perhaps, egg parasites, if any, are scarce or are not found there, so that it may be worthwhile to introduce some from other localities.

CONTROL MEASURES

Catching by net.—In China, where *Rynchocoris humeralis* has been studied to some extent, the principal method recommended for the control of the pest is catching the nymphs and adults by means of hand nets. This method has been employed here for the control of *R. serratus.* In 1932, De Leon found that the numbers of nymphs and adults were minimized by catching them with cheesecloth nets with long handles, this method having been recommended by the former plant pest control division (now plant Sanitation Division).

Light traps.—Two light traps, consisting of lantern lamps (Dietz), each placed over a basin of water and little soap were tried at Novaliches during the abundance of the bugs in July and August. Although the traps were set for five nights no green bug adults were caught, indicating that the adults were negatively photo~~graphic~~tropic to the kind of light used.

Insecticide.—A preliminary spray of soap solution showed good results in the control of the nymphs. The spray was pre-

[1] Identified from the Bureau of Science collections by Mr. Gervacio Bellosillo of the Bureau of Science.

pared according to Formula 1 and was tried on four mandarin trees infested with nymphs. The spraying was repeated at intervals of five days.

FORMULA 1

Chinese laundry soap	400 grams
Water (one petroleum canful)	20 liters

Observations made on four trees for about two weeks gave the result that the trees sprayed were freed from the nymphal infestation. The two unsprayed trees used as checks were found to lose about 12 per cent of the fruits.

The next spraying experiment was a combination of soap and nicotine sulphate. The spray was prepared according to Formula 2 and was tried on four mandarin trees infested with nymphs and adults. The spraying was done at intervals of five days as usual.

FORMULA 2

Chinese laundry soap	200 grams
Nicotine sulphate ("Black leaf 40")	40 cc.
Water (one petroleum canful)	20 liters

As a result of the spraying experiment on the four trees treated they were freed from the nymphs infestation after a period of about two weeks. The adults were also killed with this concentration. Two unsprayed trees used as checks suffered a loss of 14 per cent of the fruits. The two sprays produced no burning effect on the young fruits and foliage of the trees. The spraying outfits consisted of Gould's hand pump with 10-meters rubber hose and Bordeaux nozzle.

SUMMARY AND CONCLUSIONS

1. The citrus green bug, *Rhynchocoris serratus,* which belongs to the family Pentatomidae, subfamily Pentatominae, order *Hemiptera,* as a pest of citrus fruits in the Philippines has been found to cause considerable damage to citrus fruits in certain places in the Philippines.

2. The insect is apparently widely distributed in the Islands. In other countries it is found in British India, Malay Peninsula, Java, Sumatra, and Borneo.

3. The fruits injured by the bug becomes yellow around the punctures and from two to five days they dropped. Fruits found most susceptible were from one to five centimeters in diameter.

4. The eggs are about 2 millimeters in diameter and are laid in groups of 3 to 14 on the upper surface of the leaves. They

are creamy white when freshly laid and light yellow before hatching.

5. Egg-laying took place from 10 to 35 days after the emergence of the adult. The number of eggs laid by a female per day varied from 3 to 14 and the total number was from 80 to 253 or an average total of 153.8 eggs from each female.

6. The incubation period of the egg was from 5 to 7 days with an average of 5.72.

7. There are five instars, the first instar lasting from 3 to 5 days; the second, 5 to 8 days; the third, 5 to 8; the fourth, 5 to 9; and the fifth, 7 to 11 days, or an average of 4.35 days for the first instar; 5.8 for the second, 6.06 days for the third; 6.42 for the fourth, 9.7 days for the fifth. The life cycle from the time the eggs are laid to the time the nymph changes into adult is from 30 to 46 with an average of 38.04 days.

8. The first instar nymphs were found gregarious and fed upon the sap of the leaf. They dispersed after the first molting and they were found to stay mostly on the fruits to feed. When they were not feeding on the fruits they were seen among the leaves.

9. *R. serratus,* in all stages, was observed abundant during the months of June, July, and August, the abundance coinciding with the fruiting season. It is scarce from September to November.

10. Citrus is the only host plant observed in the course of this study. The following varieties were found most preferred: cabuyao (*Citrus hytrix*), calamondin (*Citrus mitis*), mandarin (*Citrus nobilis*), lemon (*Citrus limonia*), and lime (*Citrus aurantifolia*). The pummelo and king mandarin were observed resistant.

11. Two kinds of predators were found; namely, a mantid *Hierodula paterllifera* Serv., and the big red ant *Oecophylla smaragdina,* both preying on the nymphs.

12. The numbers of the nymphs and adults of *R. serratus* can be minimized by catching them with hand nets with long handle.

13. Light traps of Dietz lantern lamps did not attract any adults.

14. In this study, the citrus green bug was satisfactorily controlled by spraying at intervals of five days, with soap solution of two per cent strength; or with soap and nicotine sulphate, soap solution of the amount of soap being one per cent soap and *nicotine sulphate,* two-tenths per cent.

ACKNOWLEDGMENT

The writer wishes to thank Dr. Gonzalo Merino and Mr. F. Q. Otanes, chief and assistant chief, respectively, of the Plant Sanitation Division, Bureau of Plant Industry, for their helpful suggestions during the course of this investigation and for help and criticisms in the preparation of the manuscript.

LITERATURE CITED

1. DISTANT, W. L. 1902. The fauna of British India: Rhynchota **1**: pp. 213, London.

2. GUPTA, S. R. 1928. Report of Agricultural Department Assam, pp. 44–45. Cited in Review of Applied Entomology **18**: p. 242.

3. HOFFMANN, W. E. 1928. A sting-bug injurious to citrus in South China. Third proceeding of Pan-Pacific Science Cong., Tokyo, pp. 2030–2037. Cited in Review of Applied Entomology **19**: p. 260.

4. LEON, JOSE DE 1932. Citrus growing in the Philippines. Philippine Journal of Agriculture **1**: pp. 145–232.

5. MCSWINEY, J. 1919. Report of the Agricultural Department, Assam. Shillong, 1919. Cited in Review of Applied Entomology **7**: p. 492.

6. MERINO, G. 1928. Plant Pest Control Division Report. Twenty-eighth Annual Report of Bureau of Agriculture for the fiscal year ending December 31, 1928, pp. 3–256.

7. MITRA, S. R. and KHONGWIR P. C. 1928. Orange cultivation in Assam, Bul. Department of Agriculture, p. 19. Cited in Review of Applied Entomology **17**: p. 602.

ILLUSTRATIONS

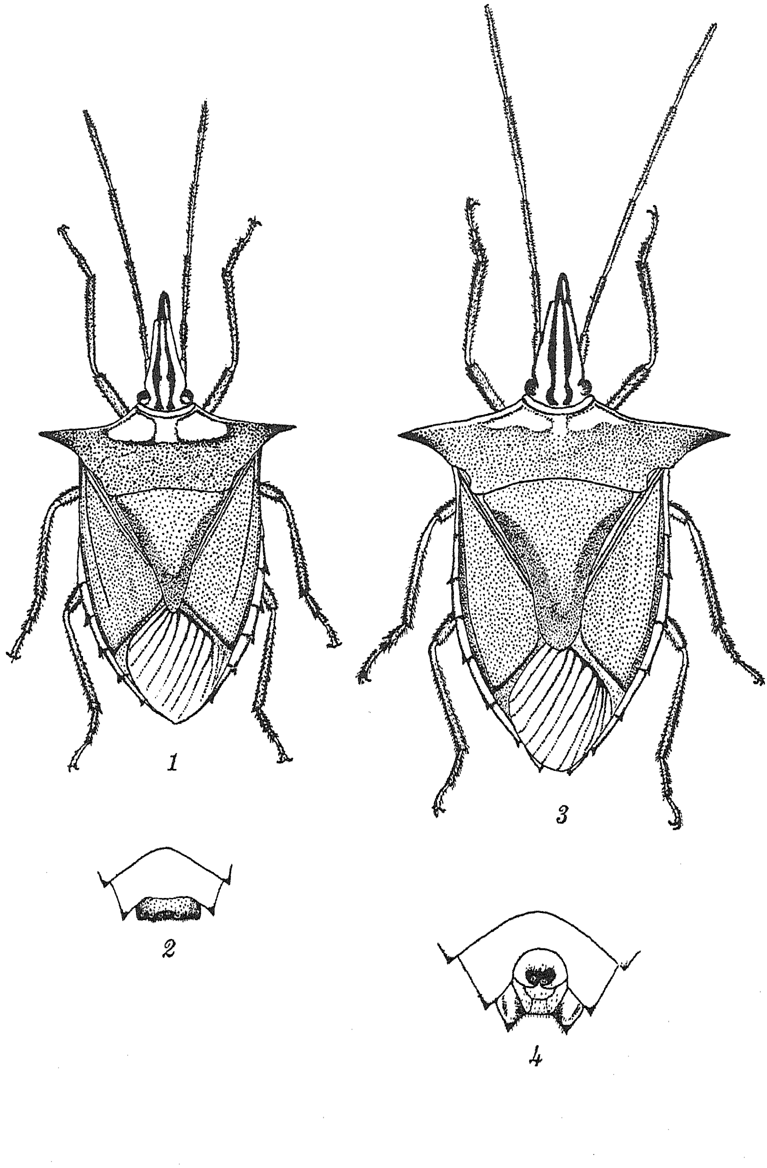


PLATE 1.

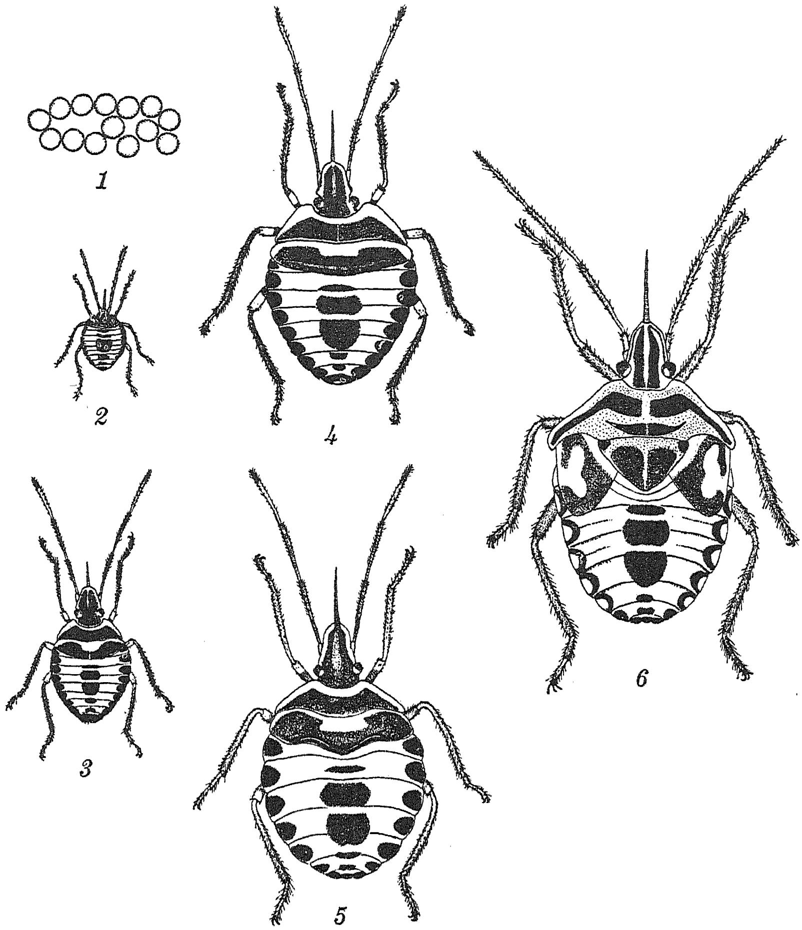


PLATE 2.

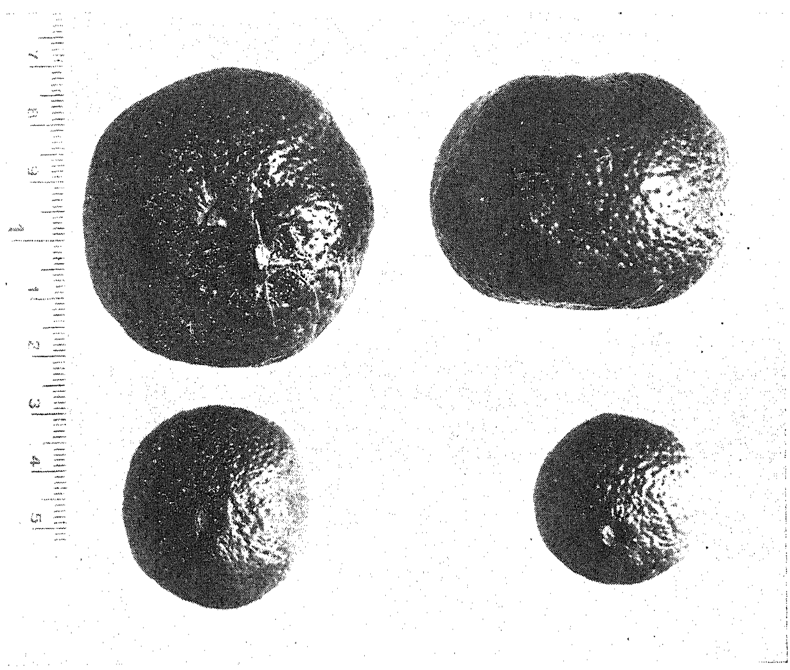


PLATE 3.

PLATE 4.

THREE BIRD CONTRIVANCES THAT ARE INDIRECTLY HARMFUL TO THE FILIPINO FARMERS [1]

By Canuto G. Manuel

Ornithologist, Fish and Game Administration
Bureau of Science, Manila

EIGHT PLATES

The willful destruction of some of our most beneficial birds through the use of air rifles, sling-shots and a bird trap known locally under the name of *bitag* or *bantay* (Tagalog), is figuratively "killing the goose that lays the golden egg." Apparently unaware of the consequences, countless number of boys even adult persons intentionally hunt song-birds with these contrivances for pastime. The harm thus done to our crops by these contrivances places them among the dangerous enemies of our farmers.

Because of the ravages of the contrivances, this study is undertaken to find out the food habits of the birds caught and killed by them. It is believed that this study would prove of value since the ravages of insects have always handicapped the farmers, and the Government has been spending thousands of pesos every year for pest control in an effort to aid the farmers in solving the world-wide problem of increasing production through increased yield per unit area. Moreover, no definite and systematic attempts have been made in this country to enhance the protection and to encourage the multiplication of birds which by far, are some of the most important natural enemies of insects. On the contrary, birds frequenting the farms have been persecuted since time immemorial.

METHODS OF STUDY

The foods of the different species of birds were determined by examining the stomach contents of materials collected in different places and at different periods. Some of the birds examined were collected by staff members of the former Section of Ornithology, principally by Mr. R. C. McGregor, dating back to 1904.

[1] Read before the Third Philippine Science Convention, February 26, 1935.

During the trips to the provinces around Manila (Laguna, Cavite, Batangas, Rizal, and Bulacan), the birds comprising the bags caught by air rifles and sling shots were noted. The names of the birds caught by *bantay* were suplied by the boys operating this trap. Occasionally, the traps were seen in action and the species of birds caught were noted.

In determining the food of birds, the volumetric method was used, i. e., the contents of the alimentary canal were considered 100 per cent by volume. The volume of the different food items were considered proportionately.

Owing to the fact that only a few stomachs were examined in some of the species of birds studied, the results herein indicated should not be considered conclusive. They are now presented merely to suspend the further destruction of beneficial birds and to create a sentiment against the use of these contrivances. Although these contrivances are obviously injurious, there is no way of obtaining quantitative estimate of the total destruction done by them.

RESULTS AND DISCUSSION

The birds caught by the three contrivances with the value of their stomach contents are given in Table 1. Stomach contents are termed injurious, neutral or beneficial depending on the importance of the group to which they belong.

Injurious food items consist mostly of larvae of insects, particularly caterpillars and grubs, and adults of grasshoppers and their allies (*Orthoptera*), termites (*Isoptera*), true bugs (*Hemiptera*), leaf hoppers and others (*Homoptera*), beetles (*Coleoptera*), flies (*Diptera*), and ants (*Formicidae, Hymenoptera*), etc. Weed seeds, fragments of wild fruits, and species of small crab are considered items of neutral importance, while spiders, dragon flies (*Odonata*), bees and wasps (*Hymenoptera*) commercial species of shrimp, crab and fish, are classified under beneficial food materials. When the percentage of the beneficial food items of a species exceeds that of the injurious items, the bird is considered injurious. Likewise a bird is regarded beneficial when its injurious food items exceed the beneficial. Rice seeds, however, may be considered both as neutral and beneficial food depending upon the way and place they were obtained. The barred ground doves were seen to pick rice seeds on the stubble(1), thus the item is considered of neutral importance, while Dussumier's turtle doves were noted to pick this material from the seed beds and in the hills where it is broad-

cast for planting. In the latter case the seeds are considered beneficial and the bird destructive.

One per cent of the food of the little yellow bittern studied consists of small locusts (*Acridiidæ*) while 90 per cent consists of shrimps (*Atyidae*), spider, dragon fly and fingerlings of dalag (*Ophicephalus striatus*).

Except Dussumier's turtle dove which was found to relish cockroaches and rice seeds, the food of five species of doves and pigeons studied comprised largely of wild fruits and weeds seeds.

The cuckoos are generally beneficial in their feeding habits and the red-winged coucal and the rufous-bellied cuckoo hold this reputation. The red-winged coucal had taken a small shrimp while one rufous-bellied cuckoo had small seeds of wild fruit in its stomach.

Fragments of a leaf-hopper and of a coconut flower were recovered from one Luzon colasisi. As this bird has oftentimes been condemned in coconut regions for its harmful effect on the fruit, the coconut flower obtained is considered beneficial and the bird is destructive in that item. Seeds of guavas were obtained from two guaiaberos examined. Of the three species of kingfishers studied the smallest (Asiatic kingfisher) is the most destructive, preying on small fishes. The white-collared kingfisher feeds on different insects to a large extent, and on miscellaneous beneficial animals, such as crab, house lizard, frog and fish to a less degree. Different kinds of beetles were obtained from nine white-throated kingfishers while in one, two small dalag (*Ophicephalus striatus*) were recovered.

The food of the black-naped flycatcher studied consists of ants, beetles, locusts and leaf-hoppers. Black and white fantail feed also on insects entirely.

In addition to destructive insects which comprise the greater percentage of the food of pied lalage, seeds of unrecognizable small fruits were also noted in the birds' stomachs studied.

The food of two species of bulbul (Philippine and guava) consists of wild fruits and insects. Fragments of both items were recovered from the stomachs of birds studied.

Dominico, pied chat and striated marsh warbler are insect-eating birds that are generally seen in or near the open field. Mosquitoes, locusts, beetles (larvae and adults), bugs, termites and seeds of cucurbitaceous plants were obtained from the stomachs of dominico studied. This bird, like the pied chat, frequents the edge of the open fields. Due perhaps to their

similarity in general habitat, the pied chat and the dominico have almost the same type of food. Except for a few weed seeds noted in one stomach of striated marsh warbler, its food consists wholly of insects. Open grasslands are favorite haunts of this species.

Our shrikes are very pugnacious, fighting fiercely other species of birds even much larger than themselves, as the hawk and the crow. They are very highly insectivorous, judging from the results obtained in this study. Various species of insect comprise the entire food of the white-bellied swallow shrikes examined. A few dragon flies and wasps were among those recovered. This species is among our most graceful insect-eating birds. They are often seen on telegraph lines in pairs or in small flocks of usually not more than ten birds. On trees, the birds prefer to stay on top so as to be able to see the surroundings for enemies and food materials which they swoop with peculiar gracefulness. They have been seen catching insects while flying.

Examination of stomachs revealed that various insects at different stages comprise the food of the Philippine red-tailed shrike (2). When they come to us in September, they immediately search the trees in our yards and gardens for insects. Decaying parts of trees are equally investigated for grubs and adult beetles, while twigs and leaves are examined for caterpillars, leaf hoppers and bugs. As they are very cheerful, especially during the first few weeks after their arrival, some people regard them as a nuisance.

The food of the large-nosed shrike, as revealed in the study of a few stomachs, is similar to that of the swallow shrike. Fragments of dragon flies and wasps were also recorded in a few stomachs of this bird as in the white-bellied swallow shrike.

Insects and fruits comprise the food of the Meyen's silver-eye. These birds were observed frequenting coconut trees. Although fragments of coconut flowers were found in some stomachs, it has not been ascertained whether they actually destroy the plant. Thus the plant materials noted in the stomachs of these birds are considered of neutral importance.

Indian pipit and Formosan skylark both feed on insects and seeds of weeds and rice. As the rice seeds were undoubtedly obtained from the ground after the harvest, judging from the the observed habits of these birds, this item is considered of neutral importance.

Based on the food of 15 birds studied, the mountain sparrow is more destructive than beneficial. The food consists of rice and weed seeds in addition to insects. Rice, however, comprises the greater percentage. These birds frequent rice fields when the grain is in head.

Philippine oriole and gray-backed coleto are known to subsist on wild fruits and examination of their stomach contents confirm this common belief. In addition to wild friuts, however, insects and fragments of papaya, (*Carica papaya*) were also noted in the food of the oriole.

TABLE 1.—*Examinatin of stomach contents of birds obtained with air rifle, sling shots and bantay.*

Common name	Scientific name	Number of birds examined	Stomach contents classified (not bird)		
			Injurious	Neutral	Beneficial
			Per cent	*Per cent*	*Per cent*
Little yellow bittern	*Ixobrychus sinensis*	6	1		99
Northern white-eared pigeon	*Phapitreron leucotis*	9		100	
Slender-billed cuckoo dove	*Macropygia tenuirostris*	1		100	
Indian bronze-winged dove	*Chalcophaps indica*	7		100	
Dussumier's turtle dove	*Streptopelia dussumieri*	15	16	69	15
Barred ground dove	*Geopelia striata*	305		100	
Red-winged coucal	*Centropus viridis*	12	98	2	
Rufous-bellied cuckoo	*Cacomantis merulinus*	8	96	4	
Luzon colasisi	*Loriculus philippensis*	1	50		50
Luzon guaiabero	*Bolbopsittacus lunulatus*	2			100
White-collared kingfisher	*Sauropatis chloris*	24	78		22
White-throated kingfisher	*Halcyon gularis*	10	90		10
Asiatic kingfisher	*Alcedo bengalensis*	4			100
Black-naped flycatcher	*Hypothymis occipitalis*	9	100		
Black and white fantail	*Rhipidura nigritorquis*	2	100		
Pied lalage	*Lalage niger*	6	73	27	
Philippine bulbul	*Iole gularis*	12	22	78	
Guava bulbul	*Pycnonotus goiavier*	16	13	73	14
Dominico	*Copsychus mindanensis*	13	92		8
Pied chat	*Pratincola caprata*	7	86		14
Striated marsh warbler	*Megalurus palustris*	10	98	2	
White-bellied swallow shrike	*Artamus leucorynchus*	50	92		8
Philippine red-tailed shrike	*Lanius lucionensis*	13	100		
Large-nosed shrike	*Lanius nasutus*	12	92		8
Meyen's silvereye	*Zosterops myeni*	6	60	40	
Indian pipit	*Anthus rufulus*	10	90	10	
Formosan skylark	*Alauda wattersi*	8	29	71	
Mountain sparrow	*Passer montanus*	15	10	34	56
Philippine oriole	*Oriolus acrorhynchus*	33	20	59	21
Gray-backed coleto	*Sarcops calvus*	5		100	
Chinese starling	*Aethiopsar cristatellus*	19	56	36	8

The food of Chinese starling or crested mynah is very similar to that of the oriole. Like the oriole and the coleto, the Chinese starling frequents trees obviously for food and shelter. In addition, however, this bird is often seen in pasture fields associating with carabaos. Stomach examinations did not confirm the common observation that this bird picks ticks, lice and other arthropods from the body of the carabao. This species oftentimes makes its home in ceiling of houses and other places close to human habitation.

THE CONTRIVANCES; THEIR EFFECTS

Air rifles.—Air rifles are quite common in the Islands. Several makes are used but the most prevalent seems to be the piston-rod air rifles of various models. These air rifles look like toy guns but in reality they are effective weapons for killing birds. The contrivance (Plate 1, fig. 1) has a simple mechanism consisting of a brass barrel about 600 mm. in length and 20 mm. inside diameter, surmounted by another much smaller barrel about 5 mm inside diameter, but having the same length. Both are supported on a wooden stock by a bolt and a nut. The bigger barrel contains the air pump and the air chamber, while the small barrel receives and expels the lead shots. The trigger connects with a valve that closes the air chamber when in position and opens it when pulled. The instantaneous release of the reserved air from the air chamber to the small barrel expels the lead shot placed at the base of the latter with great force. The gun, being dependent on air action becomes stronger or weaker depending on the number of times it is pumped before it is fired. Ordinarily, birds ranging from sunbirds to medium-sized doves fall easily with three pumpings of the piston rod. There are instances when the air rifles which ordinarily are single-shot models, are changed to repeaters (Plate 1 fig. 2) by means of ingenious devices added to the original construction. In this way, the efficiency of the rifle is greatly increased. There are also many instances when air rifles are made at home with factory-made guns as models.

Next in use to the piston-rod air rifles are the repeating pump-action air rifles (Plate 1, fig. 3), which in reality depend on spring action and not on air as the name suggests. The rifle is a miniature copy of a real pump-gun using spring for power instead of powder. Although not so powerful as the single-shot air rifle, it works havoc on our feathered friends.

Lever-action air-rifles (Plate 1, fig. 4) are also used by boys. These are high-power guns loaded with lead shots of various forms. Because they are very expensive, they are not common.

Aside from the three main types of air rifles described above, there are many other makes of air rifles in use which, although ineffective as hunting devices, contribute to the mortality of our birds.

The effects of air rifles becomes more serious when their users are taken into consideration. Usually, adult persons who can improve the mechanism of air rifles and who are familiar with the habits of birds operate these contrivances with great efficiency. As a result, there is very little chance for the hunted bird to escape death. Observation discloses that this is the most dangerous enemy of our insectivorous song birds. These birds are often encountered in thickets, grasslands, orchards and even in populated districts making them easy preys for the users of air rifles.

A survey made shows that all the birds named in Table 1 are caught with the use of air rifle.

The beneficial birds killed are:

1. Red-winged coucal.
2. Rufous-bellied cuckoo.
3. White-collared kingfisher.
4. White-throated kingfisher.
5. Black-naped flycatcher.
6. Black and white fantail.
7. Pied lalage.
8. Philippine bulbul.
9. Dominico.
10. Pied chat.
11. Striated marsh warbler.
12. White-bellied swallow shrike.
13. Philippine red-tailed shrike.
14. Large-nosed shrike.
15. Meyen's silvereye.
16. Indian pipit.
17. Formosan skylark.
18. Chinese starling.

The birds of neutral importance caught are:

1. Northern white-eared pigeon.
2. Slender-billed cuckoo dove.
3. Indian bronze-winged dove.
4. Dussumier's turtle dove.
5. Barred ground dove.
6. Luzon colasisi.
7. Guava bulbul.
8. Philippine oriole.
9. Gray-backed coleto.

THE HARMFUL BIRDS CAUGHT ARE

1. Little yellow bittern.
2. Luzon guaiabero.
3. Asiatic kingfisher.
4. Mountain sparrow.

In grouping the birds according to their importance, the harm wrought or the benefit derived from them are given an edge over their neutral effects. For example, the food of the Philippine bulbul consists of 22 per cent injurious insects and 78 per cent

wild fruits of neutral importance. Inasmuch as the insects are more important than the wild fruits in this respect the bird is thus classified as beneficial. The importance of birds that feed on injurious, neutral and beneficial foods is determined only according to the first and the third. Mountain sparrow falls under this category. When the difference in the percentage between these two items is slight the bird is considered neutral in importance. Dussumier's turtle dove, Luzon colasisi, guava bulbul and Philippine oriole fall under this group.

It should be noted that this arrangement is based upon the food of adult birds. The food of the young which in most species consist of wild seeds and larvae of insects are not considered. The aesthetic value of the birds, considered by many as important in the enumeration of benefits derived from them, was not taken into account. In the order of their occurence in the bag, the birds more commonly caught are:

1. Guava bulbul.
2. Philippine red-tailed shrike.
3. Philippine bulbul.
4. Barred ground dove.
5. Black and white fantail.
6. Pied lalage.
7. Philippine oriole.

The first three birds frequent the yard, so that they are easy preys. Because of the bigger and alleged better taste of the flesh of the barred ground dove, they are hunted in paddy fields and brush close to them. Black and white fantail and pied lalage are commonly met with in the thicket and are accidentally caught in pursuit of other birds. The Philippine oriole is generally rarer and warier than any of the other six birds, but its beautiful bright golden yellow color and its bigger size appeal to the contrivers who impatiently search for the bird.

Sling shot.—The sling shot, although a simple toy device, is an effective weapon in killing common birds. It consists of a handle and a strap. The handle is typically Y-shaped. Several materials are used for the handle, including wire of different sizes braided together, a piece of board made to fit, but generally forked twigs of heavy wood are cut to suit the desired size. When a twig is used, the bark is removed and the wood is dried. The strap is always of rubber band, the size of which depends upon the wish of the contriver. Pieces from blown-out interior tubes of automobile tires are very commonly used as straps of sling shots. Generally, each wing is 20 centimeters long by 1.5 centimeters wide by 0.2 or 0.3 centimeters thick. The two wings are joined by a piece of leather of convenient texture which holds the shot (Plate 2). The free ends of the

strap are then tied one against each end of the arms of the handle. Rubber band or cotton thread is used for tying. Pebbles of various sizes, trimmings of iron or steel and hardened mud moulded for the purpose are used for shots.

Sling shots are generally operated by boys between 7 and 15 years old. These boys romp along the roadside in the morning and in the afternoon. Studies reveal that sling shots are commoner in rural districts than in thickly populated communities. This is perhaps primarily due to the luxuriant vegetation and consequent abundance of bird life in the former. It was also observed that around the City of Manila boys play with their sling-shots more frequently during the period from September to December than during any other time of the year. This is because the red-tailed shrikes are cheerful and more abundant then. This species spends the winter in the Philippines. For a time the birds are silent owing to their wearisome flight from their summer home in North China, Korea, etc., but two or three days after their arrival, they begin to twitter and their cheerfulness results from the abundance of insects which comprise their entire food.

It is interesting to observe that of 234 boys seen in Rizal and Laguna provinces operating sling shots, 194 were attending elementary schools. This circumstance is explained by the ages of the boys operating the contrivance. It may thus be concluded that the killing of insect-eating birds through the use of sling shots may be stopped through the help of teachers and other authorities of the elementary schools. Measures along this direction are now in process.

A survey made to determine the birds killed through the use of sling shots reveal the following:

1. Philippine red-tailed shrike.
2. Guava bulbul.
3. Philippine bulbul.
4. Barred ground dove.
5. Pied lalage.
6. Black and white fantail.
7. White-bellied swallow shrike.
8. Pied chat.
9. Dominico.

It will be noted that sling-shots are less effective than air rifles in killing birds. The ease in making sling-shots and the enormous number of boys operating this contrivance are, however, important factors to consider in the number of insect-eating birds slaughtered. The status of the birds named above is indicated in Table 1. It will be seen that seven of the birds species feed on injurious insects and are thus classified as beneficial birds. No estimate of the total number of individual beneficial

birds slaughtered annually has been made, but it must be great enough to be of significance in the maintenance of the natural balance.

Bantay.—Mechanically, *bantay* is a slip-noose trap. Structurally, it consists of a stake, a spring and a catch peg (Plate 3). Bamboo ends of convenient length, generally about 2 meters long are used for stakes. Both ends are made pointed so that the smaller end sticks into the ground and the bigger one induces the bird to alight on the catch peg.

At about 80 centimeters from the free end of the stake, just above a node, a hole is made on one side. This hole is used for the insertion of one end of a flexible bamboo twig which serves as the spring of the contrivance. In order that the stake could hold the spring very well and the spring could exert a great force, the butt of the spring is inserted toward the upper end of the joint until it nearly reaches the adjoining node. The whole length of the joint is thus nearly occupied by the butt of the spring. The other end of the spring is connected to a string provided with a loop at the other end. About 5 centimeters and immediately below the top of the pointed end of the stake, a hole 0.5 centimeter is drilled. The small end of the catch peg and the string are inserted in this hole. The loop which acts as the noose of the trap is set on the catch peg. The catch peg is a sub-bamboo stick about 12 centimeters long and 1 centimeter in its greatest diameter. This serves as the release.

This contrivance is generally operated in an open field and is called *bantay* which literally means guard. The name is probably derived from the fact that the trap stands prominently in the middle of the field as a sentinel. It catches any bird that rests on the catch peg, although it is intended for perching birds only. When a bird perches on the catch peg, the peg is released downward and the loop which is pulled by the spring catches the legs of the birds.

Boys pasturing carabaos usually operate this trap. Some boys operate *bantay* in an open field not far from their house, when they cannot afford a regular inspection of their traps, so that other boys might not molest their contrivance.

There is every reason to believe that this type of snare is intended primarily for the Philippine red-tailed shrike. In the months of September, October and November each year, *bantay* is a comomn sight, particularly in rural districts. It will be noted that this is the period of greatest abundance of the red-tailed shrike. Consequently, this bird comprises the larger per-

centage of the catch of this trap. Observation indicates that the following birds, in the order of their frequency, are caught with the use of *bantay:*

1. Philippine red-tailed shrike.
2. Large-nosed shrike.
3. Striated marsh warbler.
4. White-bellied swallow shrike.
5. Pied chat.
6. Dominico.

It will be seen that only few species of birds are caught with the use of *bantay*. The list, however, shows that all birds caught with it are insectivorous. The number of bird traps in operation and the total number of birds caught by these traps are important in estimating the value of the snare. Unfortunately, there is no way to obtain the figures. Basing the conclusion on the food habits of the species caught, this contrivance is clearly injurious.

SUMMARY

1. Two courses of investigation were followed in this study, viz; (*a*) observation of the bags of air rifles, sling shots and *bantay* and (*b*) determination of the economic value of these birds based on examination of their stomach contents.

2. The birds are considered injurious, if their diet includes a greater percentage of beneficial food items than harmful foods. Birds are classified as beneficial when their injurious foods outbalance the beneficial items. When their foods are of neutral importance, or when the beneficial items nearly balance the harmful items, the species are considered of neutral value.

3. Determination of the value of the birds was based on volumetric measurements of their stomach contents.

4. The results obtained are qualitative rather than quantitative. Necessary data to estimate the numerical value of the status of the birds are impossible to obtain.

5. The economic value of the insect food items which determines the status of birds is based mainly upon the importance of the group to which the insects belong.

6. The results are presented primarily to suspend further destruction of beneficial birds and to create sentiment against the use of air rifles, sling-shots and *bantay*.

7. Different makes of air rifles are used but the piston-rod air rifle is the most prevalent in the Philippines. Single-shot piston-rod air rifles are sometimes transformed into repeating piston-rod air rifles. Other types in common use are repeating pump-action air rifles and lever-action air rifles.

8. Adults who are able to enhance the slaughtering effects of air rifles, through modification of the contrivance and through their knowledge of the habits of birds, operate them.

9. A survey made to determine the birds caught with the use of air rifles indicate that 18 species are beneficial, 9 are of neutral importance while 4 are injurious.

10. Among the 7 species of birds frequently caught with the use of air rifles, 4 are beneficial and 3 are of neutral importance.

11. Sling-shots are generally operated by boys between 7 and 15 years of age.

12. Sling shots are commoner in rural districts than in more thickly populated communities. Around the City of Manila, boys with sling-shots are more frequently seen during 4 months (September to December) than in other periods. During these months, the Philippine red-tailed shrikes are in greatest abundance.

13. About 80 per cent of the boys encountered with sling-shots in Rizal and Laguna Provinces are attending public elementary schools.

14. The bags of sling-shot studied were found to consist of 9 species of birds. Of this number, 7 are considered beneficial. The ease in making sling-shots and the enormous number of boys operating this contrivance are important factors to consider in the destruction of insect-eating birds.

15. *Bantay* or *bitag* is a slip-noose type of bird trap. It is generally operated in an open field.

16. Boys pasturing carabaos are the common operators of *bantay*.

17. Indications tend to show that *bantay* is intended primarily for the Philippine red-tailed shrike.

18. Although the red-tailed shrike comprises the larger percentage of the catch of *bantay*, 5 other highly insectivorous birds are noted to comprise the bag of this snare.

19. No concrete data on the destructiveness of *bantay* are presented as there was no way of obtaining the number of birds caught. Based on the food habits of the species recorded, this contrivance is clearly injurious.

This study indicates that the birds frequently caught with the use of air rifles, sling shots and *bantay*, are highly insectivorous and should, therefore, be regarded as friends of our farmers. It also shows that the contrivances used for slaughtering these creatures are highly destructive and are thus dangerous to the farmers.

LITERATURE CITED

1. MANUEL, CANUTO G. Food and feeding habits of the barred ground dove. Phil. Journ. Sci. LV (1934), pp. 69–77.
2. The red-tailed shrike: How it may be protected. Agricultural Life. November (1934) p. 24.

ILLUSTRATIONS

PLATE 1.

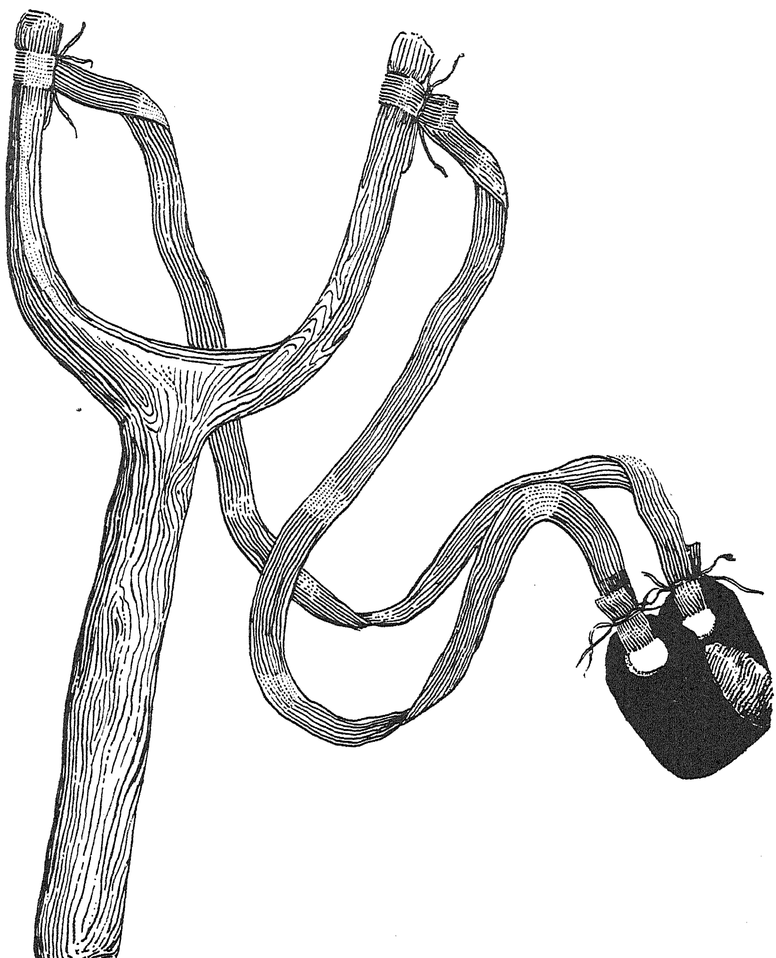
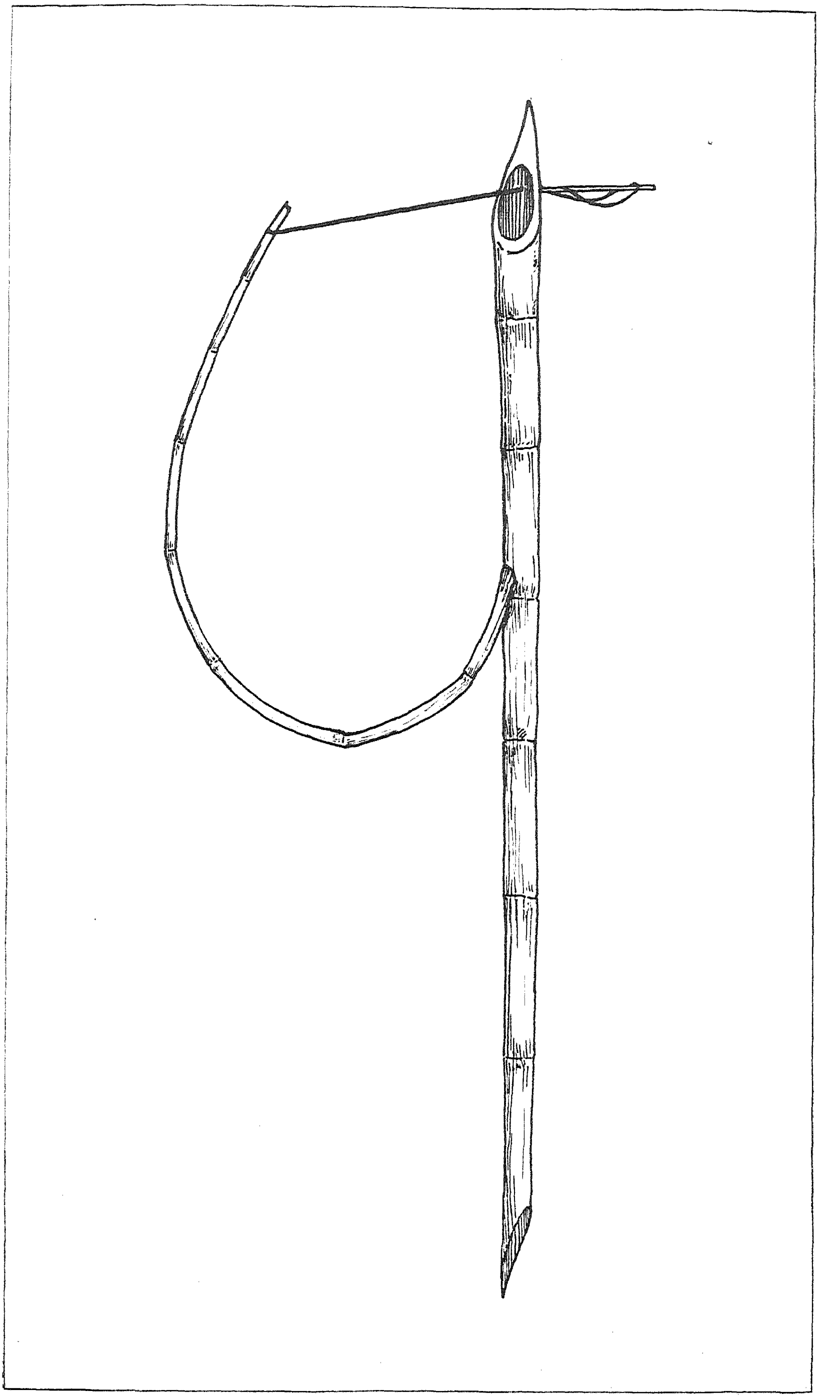


PLATE 2.



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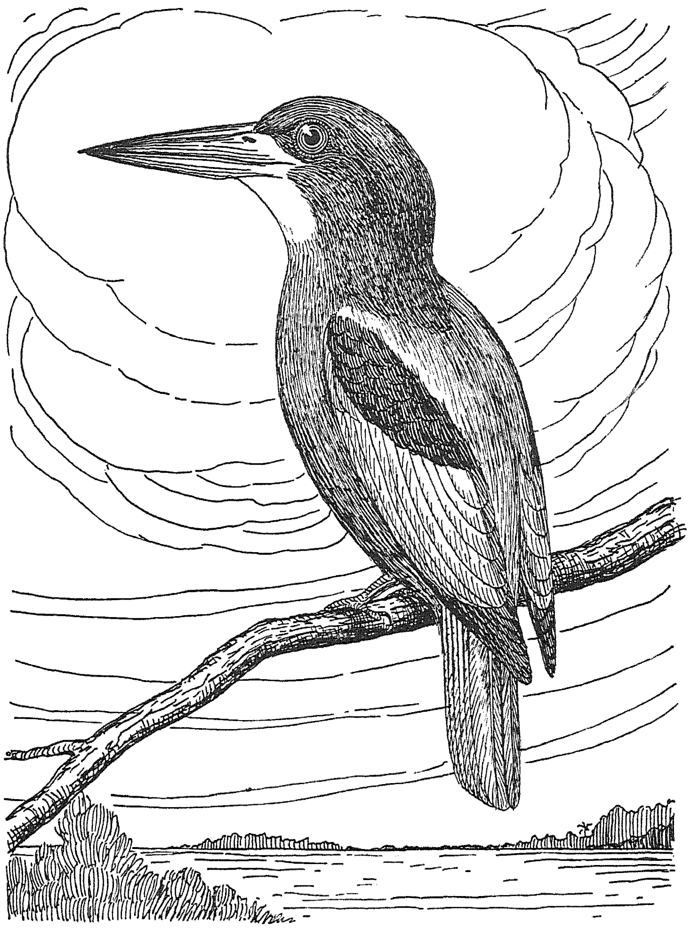
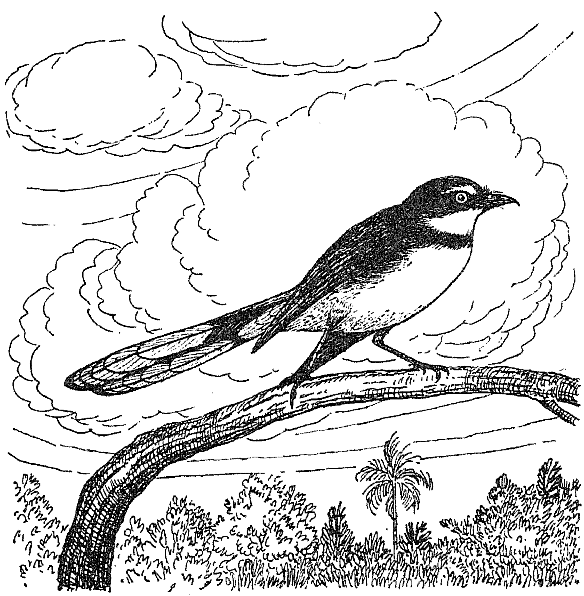


PLATE 4.



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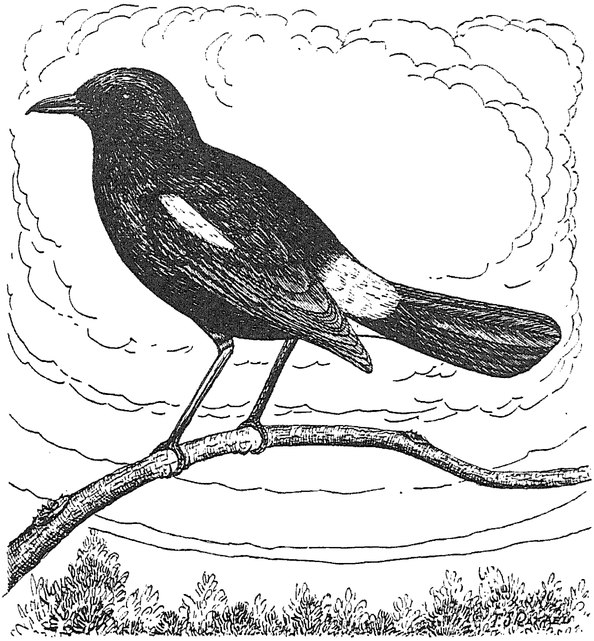

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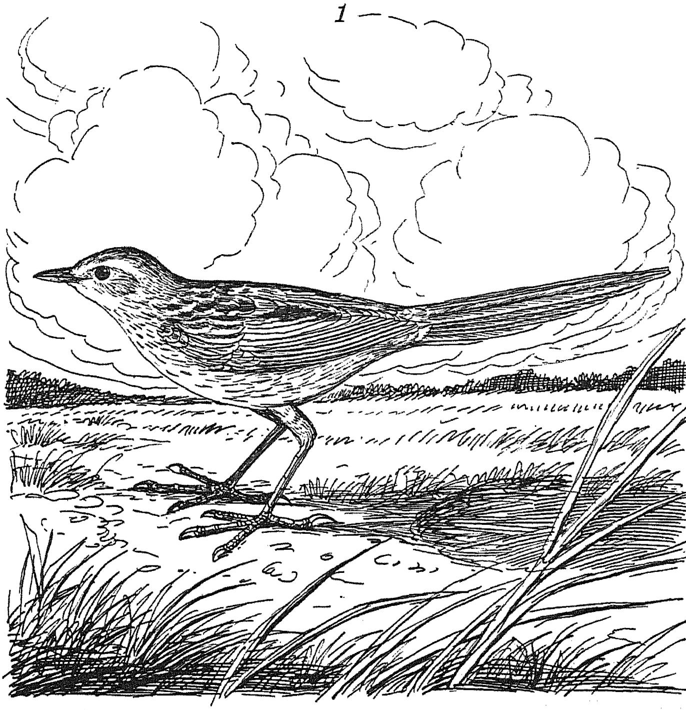

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PLATE 6.

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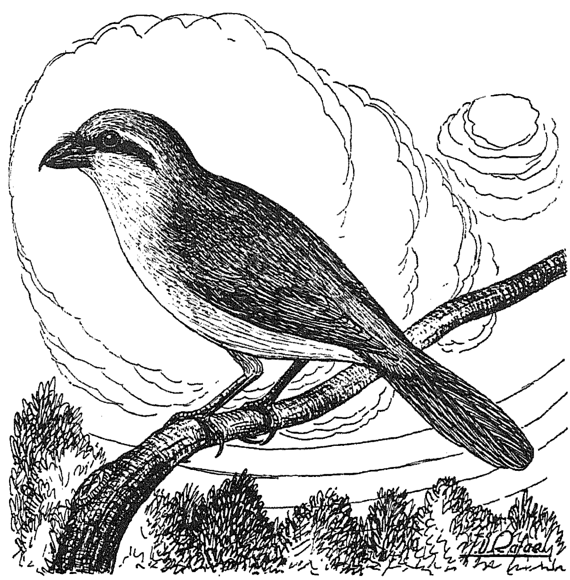

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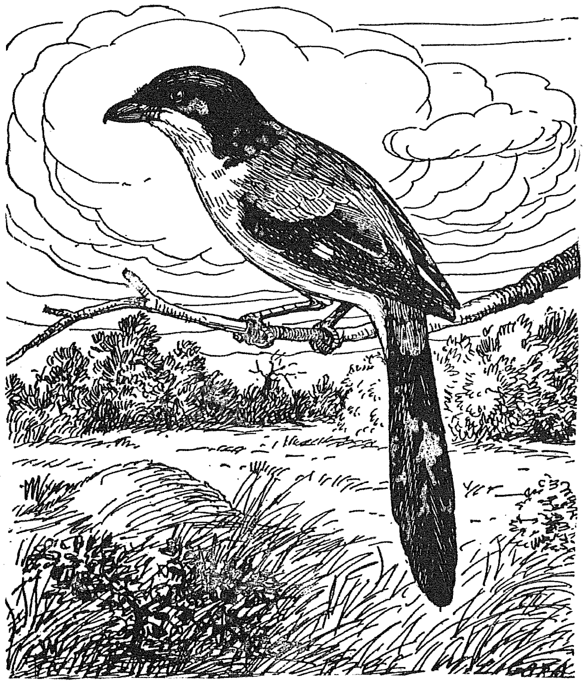
PLATE 7.



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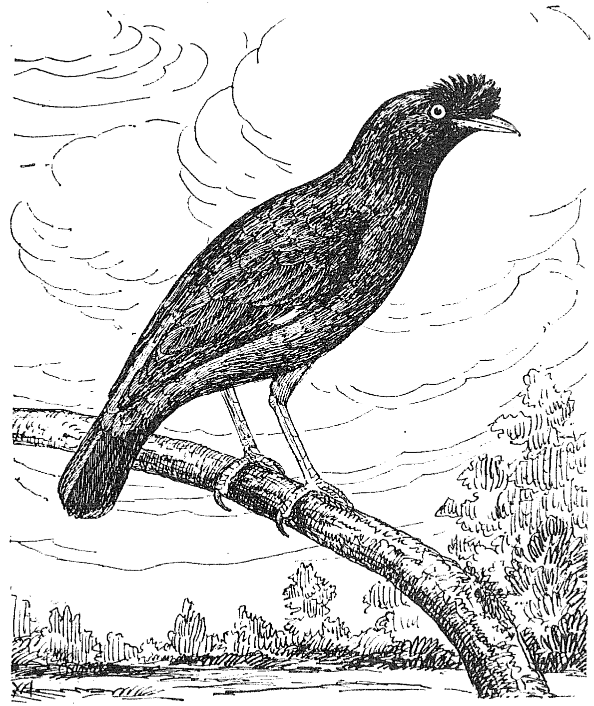

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PLATE 8.

LONGEVITY OF SOME FARM CROP SEEDS

By Pedro A. Rodrigo

Of the Horticulture Section, Bureau of Plant Industry

The duration of the life in a seed depends upon several factors. The more important of these factors are the degree of maturity at harvest; the method of gathering and curing the seed; the water content of the seed when stored; the composition of the seed; the nature of the seed coat; the method of storage; and the humidity and temperature of the air in the storing receptacle.

The proper storing of farm and garden seeds for planting has always been a vital problem to the farmer and the seed dealer. This is especially so in the Philippines because the moisture and temperature conditions throughout the year are conducive to rapid deterioration of seeds. The methods employed by our farmers and seed dealers in storing their seeds hardly exclude air, moisture, insect or fungus diseases. Imported seeds from temperate countries, particularly vegetable seeds, have been found to deteriorate in vitality very rapidly. An understanding of the factors affecting the longevity of seeds in storage is important not only to the farmers and seed dealers but also to scientists. It enables one to preserve seeds in quantities and to keep the purity of selected varieties and strains, especially of those which are given out for propagation and for commercial planting. It also enables a research worker who is testing a large number of varieties and strains, under limited means, to store part of his materials for experiment later on.

REVIEW OF LITERATURE

Several studies on the longevity of seeds have been undertaken in temperate countries. Most of these studies relate to herbarium specimens, excavated seeds and buried seeds. They include both wild and domesticated plants and attempt to determine the factors affecting the life in the seeds. Although such studies, especially those dealing with seeds of cultivated plants, should prove of great practical value in tropical countries, particularly in the Philippines, they have not as yet received due attention from research workers here.

How long seeds are capable of remaining viable has always been an interesting question. Some impressions have prevailed that seeds are able to retain their vitality for long periods even if buried in the soil. The desire to check such impressions prompted Ewart and White (1908) to test for germination many herbarium samples of seeds of known age. These researchers found that many of the seeds which germinated were over 100 years. Ohga (1923), in a recent work on the germinative power of excavated seeds of *Nelumbo nucifera* in Manchuria, estimated its longevity to be 120 years or more.

The first attempt to obtain definite data on the length of time seeds are able to retain their vitality while buried in the soil so far as the writer is aware was made by Dr. W. J. Beal, of the Michigan Agricultural College in 1879. He buried at East Lansing, Michigan, 20 inverted open-mouth bottles, every bottle containing 50 seeds of each of 20 species. One bottle was taken up every 5 years. The last available report (1922) was made after 40 years, at which time 10 of the 20 species produced sprouts when tested. In 1902, according to Goss (1925), Dr. J. Duvel, of the Seed Laboratory of the U. S. Department of Agriculture, started the buried seeds experiment, following the general plan of Dr. Beal, but he used seeds of a larger number of species and subjected them to more natural conditions. He used 112 samples of seeds, representing 107 species. After one year he found that seeds of domesticated plants failed to germinate. Seeds of wild plants, however, were still capable of germination, the percentage of germination varying from a few per cent to over 50 per cent. The seeds which were buried deeper showed stronger vitality.

About 22 years later, Goss (1925) made a report of Dr. Duvel's experiment on buried seeds. He found out that "of the 107 species buried in 1902, 71 grew in 1903 after one year; 61 grew in 1905 after three years; 68 grew in 1908 after 6 years; 69 grew in 1912 after 10 years; 50 grew in 1918 after 16 years; and 51 grew in 1923 after 20 years."

On the causes of loss in the vitality of seeds Duvel (1904) conducted a series of studies. This was started in 1899 in the University of Michigan and was continued in the Seed Laboratory of the U. S. Department of Agriculture. The part of his findings that may be of immediate interest may be briefly summarized as follows: (1) That there was a close relationship between the precipitation and the loss in vitality in seed. The deterioration was more apparent with an increase in temperature,

but the injury caused by the increase in temperature was dependent upon the amount of moisture present. (2) The seeds which were exposed in a moist atmosphere to the higher temperature (36–37° C.) were killed much earlier than those subjected to the moist atmosphere at lower temperatures (30–32° C.) But, even at these lower temperatures, the deterioration of viability was comparatively rapid. Comparatively moist seeds in sealed bottles lost their viability sooner and more rapidly. (3) The seeds when kept dry were not injured by prolonged exposures to temperature below 37° C. whether in open or sealed containers. (4) The viability of seeds not well dried was better maintained at temperature just above freezing point, provided the temperature remained constant.

OBJECT OF THE STUDY

The original object of this study was to find an economical and practical way of storing farm crop seeds under Philippine conditions. Incidentally, the longevity of the seeds under different methods of storing was determined.

HISTORY

This study was started at the Los Baños College of Agriculture in January, 1924. The work was planned by Doctor Vibar [1] and the writer, and for the first five years the work was undertaken in the laboratory of the Division of Farm Crops, College of Agriculture, U. P. These results were published in the Proceedings of the Third Pan-Pacific Science Congress in Tokyo in 1926, and later in the *Philippine Agricultural Review* Vol. 22, No. 2, in 1929.

When the writer left the College of Agriculture in the early part of 1929, he deemed it wise to get one-half of the materials under study so as to insure the continuance of the work. These seeds were brought to Manila, to the Central Luzon Agricultural School, Muñoz, Nueva Ecija, to the Baguio Semi-temperate Fruit Station, Baguio, Benguet, and finally to the Central Experiment Station, Bureau of Plant Industry where the work is still in progress. New seeds, particularly vegetables, have been lately added to the materials under study. The seeds were tested in the different places at three months intervals except as indicated in the results.

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[1] TORIBIO VIBAR, formerly Assistant Professor in Agronomy, U. P., and Chief Agronomist, Bureau of Plant Industry, now Editor of "Agricultural Life."

From April 15, 1929, to June 15, 1929, the test should have been done in Manila but no determination was made. From September 20, 1929, to September 20, 1930, the germination tests were made in the Central Luzon Agricultural School, Muñoz, Nueva Ecija; while from November 5, 1930, to August 5, 1932, the tests were made at the Baguio Semi-temperate Fruit Station, Baguio. From September 21, 1932, up to the present, the germination tests have been performed at the Central Experiment Station, Bureau of Plant Industry, Manila. The seeds were kept under ordinary room temperature.

MATERIALS AND METHODS

The different seeds used in this study, together with the date when they were harvested and stored, are presented in Table 1.

TABLE 1.—*A list of the seeds used, with the date of harvesting and of storing.*

Kind of seed	Date harvested	Date stored
Rice (*Oryza sativa*):		
Inintiw	Jan. 15, 1924	Mar. 12, 1924
Hambas	Jan. 15, 1924	Mar. 12, 1924
Corn (*Zea Mays*):		
Calauan Yellow Flint	Feb. 9, 1924	Mar. 12, 1924
Moro	Feb. 15, 1924	Mar. 12, 1924
Australian Yellow Dent	Feb. 12, 1924	Mar. 12, 1924
Mungo (*Phaseolus aureus*):		
Dull Yellow	Mar. 7, 1924	Mar. 12, 1924
Cowpea (*Vigna sinensis*):		
New Era	Mar. 5, 1924	Mar. 12, 1924
Tapilan (*Phaseolus calcaratus*):		
Black	Feb. 15, 1924	Mar. 12, 1934
Yellow	Jan. 23, 1924	Mar. 12, 1924

Before storing, the seeds were first dried on a cement floor until they no longer lost in weight. This drying required from three to six days varying with the different kinds of seeds. This was done on the belief that air-dry seed would not lose moisture when stored in sealed container under ordinary room conditions and on the strength of the findings of Harrington and Crocker (1918) "that the percentage of germination was not materially changed when seed of wheat, barley, Sudan grass, Kentucky bluegrass and Johnson grass was dried to less than 1 per cent of moisture." The seeds were stored under three sets of conditions:

(1) in sealed containers; (2) in sealed containers with naphthalene; and (3) in cloth bag. With every test made, the sample was drawn from the containers after which the sealed containers were again made air-tight. Ordinary garden soil put in boxes was used as germinating medium. Only seeds that were able to send their plumules out of the soil were considered germinated.

RESULTS AND DISCUSSION

While the experiment was started in 1924, the data here presented were only those obtained from 1928 up to June 21, 1935. The study is still in progress.

Tables 2 and 3 present the results obtained from the rice and corn samples, respectively, while Table 4 gives similar data obtained from legume seeds.

TABLE 2.—*Showing the longevity of rice seeds under different methods of storing.*

Date tested	Age of seed from date of storing	Variety Hambas		Variety Inintiw	
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed
1924	*Month*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
April 2	----------	[a] 97	----------	[a] 98	----------
1928					
October 15	55	60	80	80	92
December 15	57	72	76	60	84
1929					
February 15	59	64	56	48	84
April 15	61	----------	----------	----------	----------
June 15	63	----------	----------	----------	----------
September 20	66	56	48	40	76
December 20	69	48	44	32	68
1930					
March 20	72	20	16	12	48
June 20	75	8	12	0	36
September 20	78	----------	----------	----------	----------
November 5	79.5	0	4	4	16
1931					
February 5	82.5	0	0	0	12
May 5	85.5	0	0	0	4
August 5	88.5	----------	----------	0	0
November 5	91.5	----------	----------	----------	0

[a] Initial.

TABLE 3.—*Showing the longevity of corn seeds under different methods of storing.*

Date tested	Age of seed from date of storing	Calauan Yellow Flint		Moro		Australian Yellow Dent	
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed
1924	*Month*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
March 15	--------	[a] 100	--------	[a] 100	--------	[a] 100	--------
1928							
October 15	55	44	36	0	20	0	92
December 15	57	36	32	4	12	0	92
1929							
February 15	59	40	28	0	0	4	64
April 15	61	--------	--------	--------	--------	--------	--------
June 15	63	--------	--------	--------	--------	--------	--------
September 20	66	32	24	0	0	0	52
December 20	69	32	20	0	0	0	44
1930							
March 20	72	24	8	--------	--------	--------	32
June 20	75	12	0	--------	--------	--------	32
September 20	78	--------	--------	--------	--------	--------	--------
November 5	79.5	0	0	--------	--------	--------	4
1931							
February 5	82.5	0	0	--------	--------	--------	0
May 5	85.5	0	--------	--------	--------	--------	0
August 5	88.8	--------	--------	--------	--------	--------	0

[a] Initial.

TABLE 4.—*Showing the longevity of some leguminous seeds under different methods of storing.*

Date tested	Age of seed from date of storing	Cowpea		Mungo		
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed	Cloth bag
1924	*Month*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
March 15	----------	[a] 99	----------	[a] 100	----------	----------
1928						
October 15	55	96	88	88	92	32
December 15	57	88	76	100	96	0
1929						
February 15	59	80	68	92	88	0
April 15	61	----------	----------	----------	----------	----------
June 15	63	----------	----------	----------	----------	----------
September 20	66	84	80	96	88	0
December 20	69	88	88	92	92	0
1930						
March 20	72	88	84	88	92	----------
June 20	75	80	84	88	88	----------
September 20	78	----------	----------	----------	----------	----------
November 5	79.5	76	76	92	84	----------
1931						
February 5	82.5	80	84	92	84	----------
May 5	85.5	80	88	92	80	----------
August 5	88.5	76	68	84	84	----------
November 5	91.5	72	52	76	88	----------
1932						
February 5	94.5	76	64	88	84	----------
May 5	97.5	72	60	88	92	----------
August 5	100.5	52	44	84	76	----------
September 21	102	36	56	84	68	----------
December 21	105	36	80	92	80	----------
1933						
March 21	108	8	64	92	84	----------
June 21	111	3	30	97	60	----------
September 21	114	0	12	84	48	----------
December 21	117	0	8	100	36	----------
1934						
March 21	120	0	8	92	36	----------
June 21	123	0	0	88	32	----------
September 21	126	0	0	84	24	----------
December 21	129	----------	0	92	28	----------
1935						
March 21	132	----------	----------	88	24	----------
June 21	135	----------	----------	85	11	----------

[a] Initial.

TABLE 4.—*Showing the longevity of some leguminous seeds under different methods of storing*—Continued.

Date tested	Age of seed from date of storing	White Tapilan		Black Tapilan		
		Sealed with naphthalene	Sealed	Sealed with naphthalene	Sealed	Cloth bag
	Month	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1924						
March 15		[a] 96		[a] 80		
1928						
October 15	55	64	76	48	80	40
December 15	57	68	48	60	44	28
1929						
February 15	59	80	52	64	60	16
April 15	61					
June 15	63					
September 20	66	76	64	72	68	28
December 20	69	76	68	76	76	28
1930						
March 20	72	72	72	84	80	24
June 20	75	76	64	88	80	16
September 20	78					
November 5	79.5	72	68	84	88	20
1931						
February 5	82.5	68	72	88	84	16
May 5	85.5	68	68	88	80	20
August 5	88.5	60	64	92	84	20
November 5	91.5	56	56	76	92	24
1932						
February 5	94.5	72	56	84	92	20
May 5	97.5	64	44	84	92	24
August 5	100.5	64	12	68	88	24
September 21	102	32	16	76	88	16
December 21	105	48	28	96	80	28
1933						
March 21	108	60	28	92	96	24
June 21	111	30	12	90	93	33
September 21	114	16	20	92	88	32
December 21	117	20	16	80	92	20
1934						
March 21	120	24	12	84	88	36
June 21	123	28	0	80	72	12
September 21	126	16	0	84	72	20
December 21	129	20	4	84	80	16
1935						
March 21	132	4	8	72	72	24
June 21	135	12	4	68	88	12

[a] Initial.

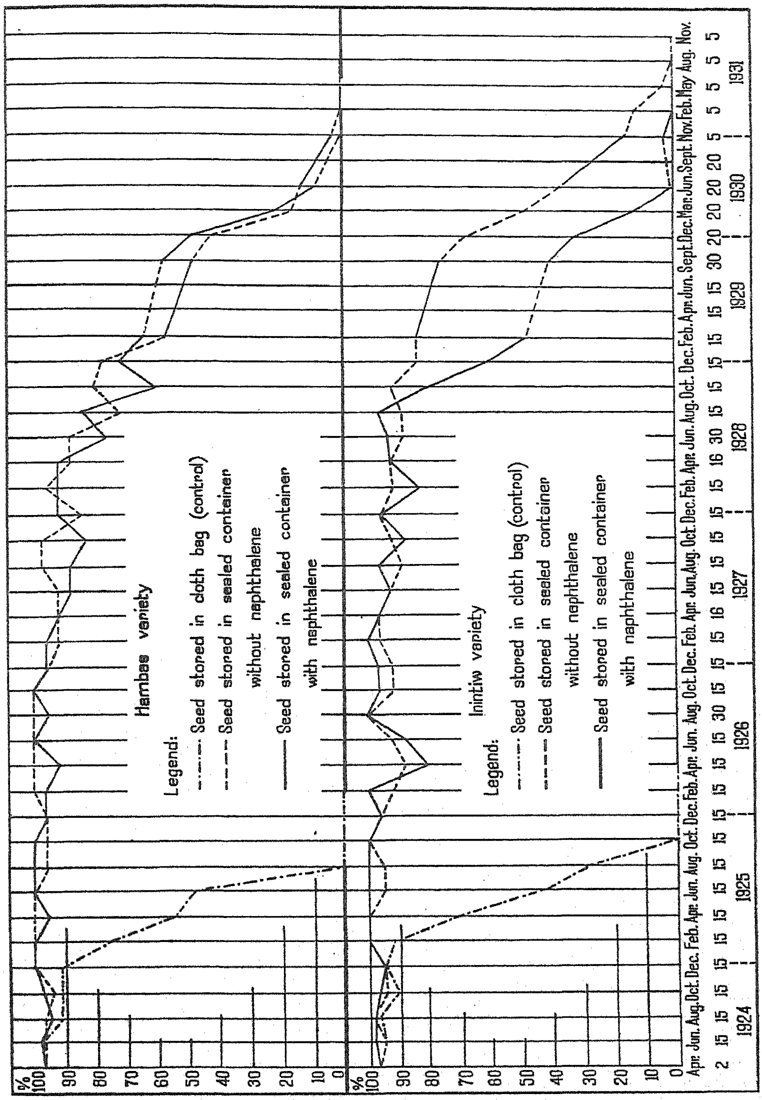

CHART 1. Showing the march of germination of rice seed stored under three sets of condition.

It will be noticed in Tables 2 and 3 that all the rice and corn seeds have already completely lost their viability, whereas in Table 4 it will be seen that some of the legumes like *Phaseolus calcaratus* (tapilan) and mungo were still maintaining a high percentage of germination when tested on June 21, 1935, exactly eleven years and three months after the experiment was started. The legume seeds, as a whole, remained viable for a longer period under the same conditions of storage than is the case of cereal

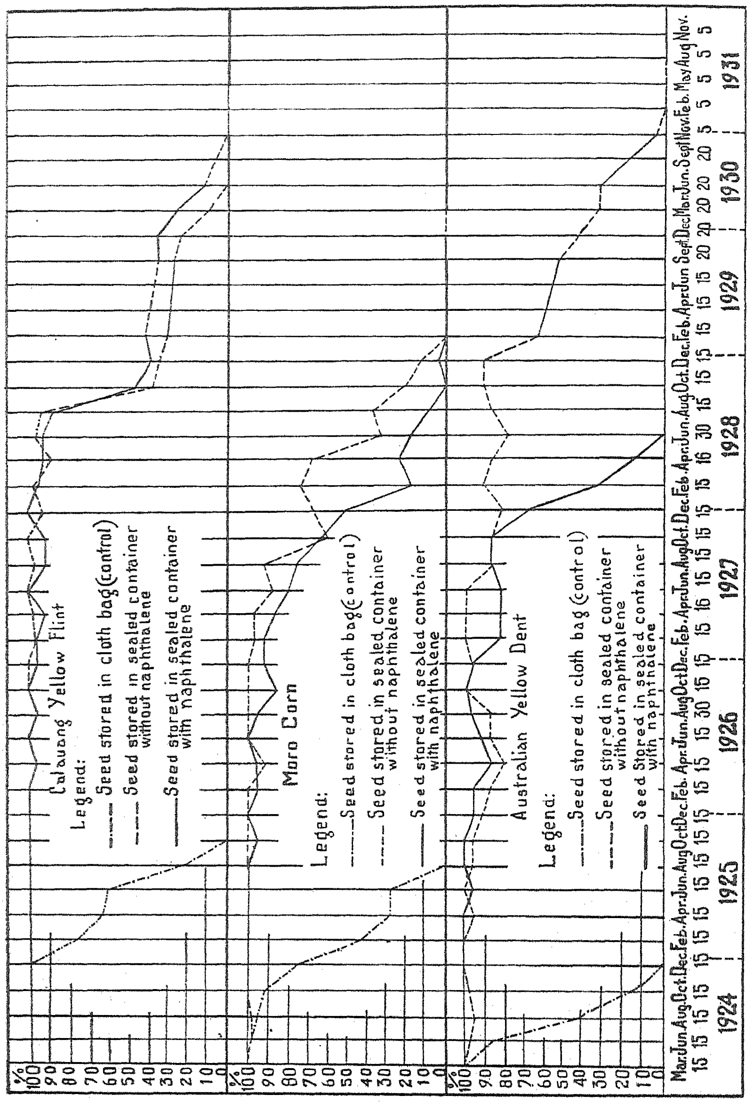

CHART 2. Showing the march of germination of corn seed stored under three sets of condition.

seeds. Oily legumes like peanut and soybean, however, lost their viability very much sooner than cereal seeds.

As seen in Tables 2, 3 and 4 and very well illustrated in graphs Nos. 1 to 4, the seeds stored in sealed containers either with or without naphthalene had very much longer span of life than the control. The seeds that were used as control (stored in non-air-tight containers), with the exception of tapilan (black

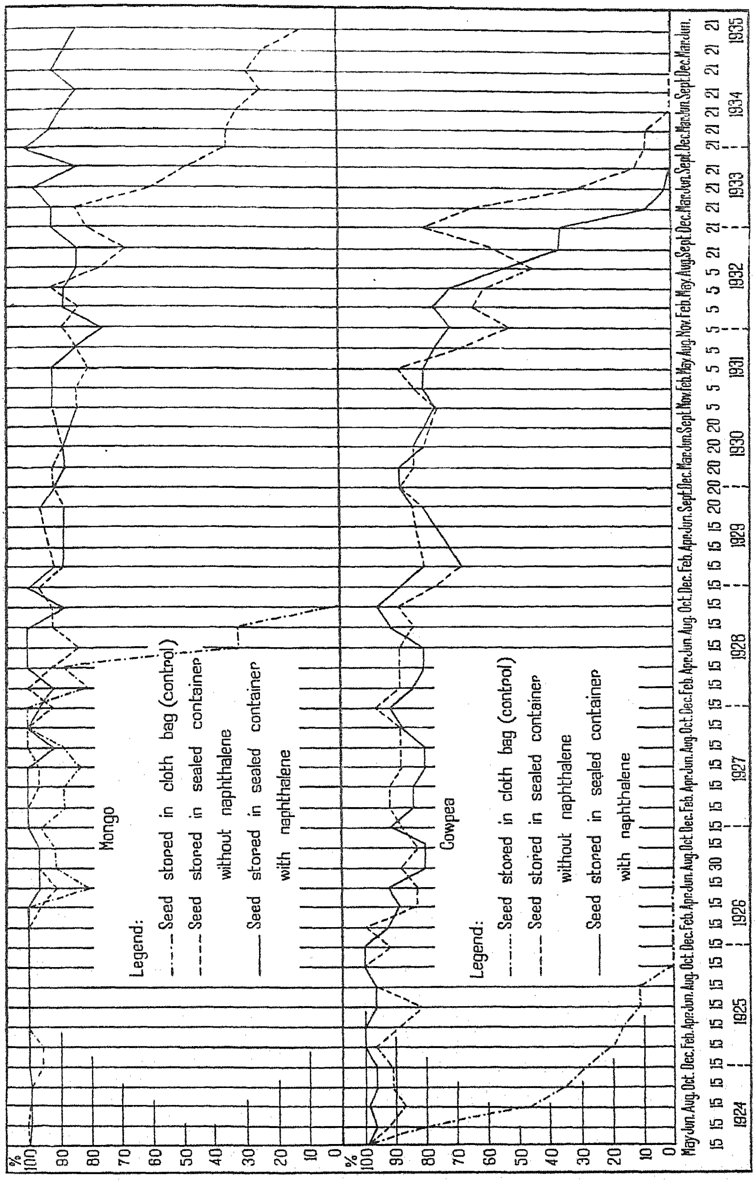

CHART 3. Showing the march of germination of mungo and cowpea stored under three sets of condition.

variety) which was still showing some signs of weak viability at this writing, showed life duration varying from 19 to 21 months for rice, 8 to 20 months for corn, 18.7 months for soybean, 16.5 months for peanut, 26.7 months for tapilan (white variety), and 57 months for mungo. The seeds in the sealed

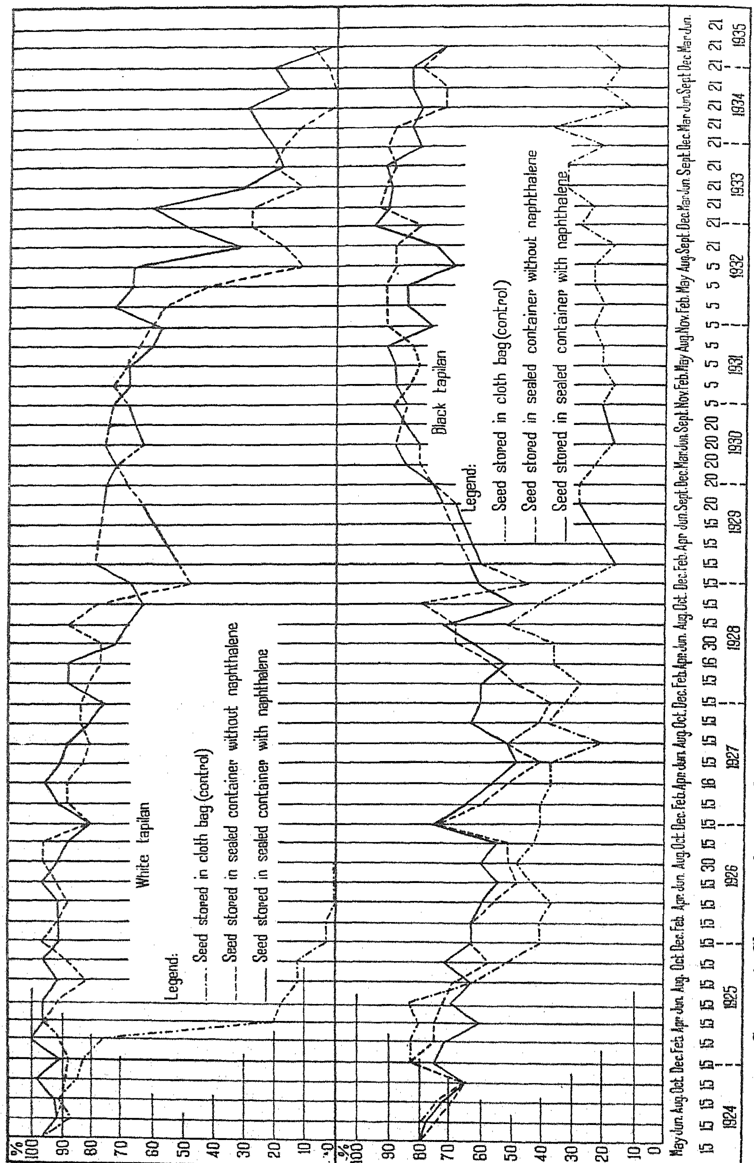

CHART 4. Showing the march of germination of tapilan seeds stored under three sets of condition.

containers with or without naphthalene, excepting mungo and tapilan, which at this writing were still showing signs of fair viability, showed life duration in storage varying from 79.5 to 85.5 months for rice, 63 to 82.5 months for corn, 54 months for

soybean, 36.5 months for peanut, and 114 to 123 months for cowpea.

Where the seeds were stored with naphthalene (see Tables 2, 3 and 4) some slight ill-effect on the longevity of the seeds was noticeable. This ill-effect, however, seemed to have been apparent only after the seeds have shown some signs of being critical. In rice and corn, there was a slight difference in the duration of life of the seeds stored in sealed containers with or without naphthalene in favor of the untreated seeds. However, in the case of cowpea and Australian Yellow Dent, a soft and starchy variety of corn, the seeds stored without naphthalene outlived those with naphthalene by over 9 and 20 months, respectively. In the case of mungo and tapilan, on the other hand, no apparent effect of napthalene has so far been noticed.

The result of this study should be of great help to the farmers and seed dealers since they can store their seeds better and for longer periods as air-dry seeds with the use of sealed or airtight containers. The result has also a very important bearing on the preservation of valuable seeds for scientific investigation. It makes possible the storing of seeds in quantities for longer or shorter periods, thus keeping the purity of selected strains or varieties particularly those which are given out for propagation and for commercial planting. Plant breeders who are testing a large number of varieties and strains, under limited means, can take advantage of the result reported in this paper in that they can store part of their materials to be tested gradually in later years.

Empty petroleum cans make handy containers; they can be piled neatly and they can be shipped easily. Such containers can be sealed with paraffin or sealing wax, preferably the latter as the former is liable to melt when exposed for some time in the sun.

There is a very interesting phenomenon brought out in this study which as far as the writer has been able to ascertain with available literature has not yet been reported before. The graph on the march of germination of black tapilan (see graph No. 4) showed in a striking way that there was a rise in the percentage of germination after it had shown some signs of being critical from the fifty-fifth to the sixty-ninth months in storage as already reported (1929). It will be noticed in table 4 that the seed in the sealed containers with or without naphthalene gave a percentage of germination ranging from 44 to 80 with an average of 64.8 from the fifty-fifth to the sixty-ninth month in

storage. However, from the seventy-second month to December 21, 1934, 129 months after storage, the seed showed a strikingly stronger viability than in the previous months. The percentage of germination during this period ranged from 68 to 96 with an average of 84.7 for that in sealed container with naphthalene, and from 72 to 96 with an average of 85.5 for that without naphthalene.

The above facts made the writer reëxamine the germination performances of the other seeds under study. The data on the other legumes like mungo, cowpea, and white tapilan exhibited the same phenomenon of renewed vigor of viability after some indications of being critical have been recorded although in a lesser degree. The same manifestation could hardly be noticed in the case of starchy seeds like rice and corn. But even here, it could not be said with certainty that the same phenomenon was not exhibited. Perhaps, because of the rather long intervals between the dates of testing the seeds, the true course of the viability was not shown.

According to Crocker (1916), "some seeds capable of immediate germination can be thrown into a secondary dormancy by a period in a germinator lacking one condition necessary for germination or involving a substance inhibiting germination or one hardening the colloids of the coats." Of course, with more age, hardening the colloids of the coats is liable to happen, but this theory cannot hold true in the present case because of the fact that older seeds of the same kind were capable of better germination without any further treatment. It appears that this renewed life activity after a period of semidormancy without any change of treatment as shown by the black tapilan seed is a natural phenomenon manifested in many other ways in the life of both plants and animals.

SUMMARY OF CONCLUSIONS

This paper presents partial results of an eleven-year study on the longevity of some farm crop seeds kept under three different methods of storage. Two varieties of rice, three of corn, one each of cowpea and mungo, and two of tapilan were the subjects of this study.

Seeds stored in sealed or air-tight containers remained viable for a very much longer period than those stored in cloth bags or non-air-tight containers where the seeds were affected by the relative humidity of the air.

Seeds in sealed containers like legumes were capable of showing renewed vigor of viability after they had shown signs of being critical. The phenomenon was well illustrated in the case of black tapilan, a variety of *Phaseolus calcaratus*. This seems to be a natural phenomenon manifested in other ways in the life of plants and animals.

The legume seeds with the exception of the oily ones like soybean and peanut had longer spans of life than cereal seeds.

The life duration of the seeds in the air-tight containers varied with the kind of seed, e. g., 79.5 to 85.5 months for rice, 63 to 82.5 months, for corn, 114 to 123 months for cowpea, 54 months for soybean, 36.5 months for peanut, and over 135 months for mungo and tapilan. Mungo and tapilan seeds in sealed containers with or without naphthalene were still showing signs of fairly strong viability after 135 months (11 years and 3 months) in storage. The white variety of tapilan, however, was very critical at this period.

Naphthalene semed to have some ill-effect on the longevity of seeds in air-tight containers. In the case of rice, corn and cowpea which have already completely lost their viability, naphthalene seemed to have partially hastened the dying out of the seeds after they have shown some signs of being critical.

ACKNOWLEDGMENT

The writer wishes to express his sincere gratitude to Dr. Vicente C. Aldaba, Chief of the Fiber Research Section of this Bureau for his valuable suggestions and criticisms during the preparation of the manuscript.

LITERATURE CITED

1. CROCKER, WM. Mechanics of dormancy in seeds. American Jour. Bot. 3 (1916) 99–120.
2. DARLINGTON, H. T. Dr. W. J. Beal's seed-viability experiment. Amer. Jour. Bot. 9 (1922), 266–269.
3. DUVEL, J. W. T. The vitality and germination of seeds. U. S. D. A. Bull. No. 58 (1904).
4. EWART, A. J., and J. WHITE. On the longevity of seeds. Proc. Roy. Soc. Victoria 21 (1908) 1–210, illus.
5. GOSS, W. L. The vitality of buried seeds. U. S. D. A. Jour. Agric. Res. 29 (1925), 349–362.
6. HARRINGTON, G. T. and WM. CROCKER. Resistance of seeds to desiccation. U. S. D. A. Jour. Agric. Res. 14 (1918), 525–532.
7. OHGA, ICHIRO. On the longevity of *Nelumbo nucifera*. The Bot. Mag. Tokyo 17 (1923), 87–95.
8. VIBAR, T. and P. A. RODRIGO. Storing farm crop seeds. The Phil. Agric. Rev. 22 (1929) 3–14.

AGRICULTURAL ABSTRACTS

DORMANCY AND MATURITY OF COTTONSEED

By D. M. SIMPSON, Associate Agronomist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

Experiments conducted at James Island, near Charleston, S. C. indicate that freshly opened cotton bolls contain a considerable percentage of dormant seed. This dormancy may be eliminated by drying and storing the seed for a short period. There was no appreciable difference in dormancy of fresh seed among several upland varieties; the sea-island strain tested showed practically no dormancy.

Studies of seed maturity indicated that cottonseed reaches maturity shortly before the bolls begin to open; at James Island, S. C., this period is from 40 to 50 days after flowering. (Adapted from the Journal of Agricultural Research, Vol. 50, No. 5, March 1, 1935, pp. 427–434.)

VIABILITY OF COTTONSEED AS AFFECTED BY FIELD CONDITIONS

By D. M. SIMPSON, Associate Agronomist and B. M. STONE, formerly Assistant Scientific Aid, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

The following summary is given:

Seasonal fluctuations in the germination of cottonseed have been attributed to climatic conditions during the harvesting season, but the definite relationship of rainfall, humidity and temperature to the viability of the seeds has received little attention. Experiments conducted at James Islands, S. C., in 1931, 1932 and 1933, under conditions of frequent rainfall and high humidity, provide information on these conditions.

Cotton harvested at James Island normally contains excessive moisture. Determinations of the moisture content of seed during the period of boll opening showed that seed from bolls just cracking open contained approximately 50 per cent moisture and that seed from partially opened bolls, which are ordinarily

harvested by the pickers, may contain more than 28 per cent moisture. Dry weather caused rapid reduction in the moisture content of the seed and seed cotton, but rainy, humid or cool weather prevented drying and delayed boll opening.

The low viability of seed harvested in unfavorable weather indicates that seed deterioration occurs in the field before harvesting. Seed from bolls just opening, when dried and stored for a short time, gave higher germination percentages than seed which had been exposed for longer period in the field.

Data on the viability of seed taken from bolls exposed for varying lengths of time in the field showed that deterioration of the seed was correlated with rains or humid conditions which prevented the prompt drying of the seed cotton after the bolls began to open. Seed from bolls opening and harvested during periods of dry weather gave higher germination percentages than did seed from bolls opening and harvested during rainy weather. Differences in resistance to field deterioration were apparent among the varieties tested, and the possibility of improvement in the germinating qualities of cottonseed by selective breeding is suggested. (Adapted from the Journal of Agricultural Research, Vol. 50, No. 5, March 1, 1935, pp. 435–447.)

RELATION OF MOISTURE CONTENT AND METHOD OF STORAGE TO DETERIORATION OF STORED COTTONSEED

By D. M. SIMPSON, Associate Agronomist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

The following summary is given:

Storage experiments with sea-island and upland cottonseed under the humid conditions prevailing at James Island, S. C., showed that in ordinary storage, cottonseed deteriorates rapidly after 2 years. A definite relation is indicated between the moisture content of the seed during storage and the rapidity of deterioration. Sea-island seeds with a moisture content reduced below 8 per cent, when stored in tin containers to prevent rapid re-absorption of moisture, retained their germination percentage with only slight impairment for 4½ years. Upland cottonseed stored under various conditions and containing from 8.75 to 13.78 per cent moisture deteriorated rapidly when the moisture in the stored seed remained above 10 per cent. Dried seed stored to prevent re-absorption of moisture showed only slight deterioration after 2½ years. Seed containing 13.78 per cent

moisture and stored to prevent drying were all dead 9 months after the beginning of storage. (Adapted from the Journal of Agricultural Research, Vol. 50, No. 5, March 1, 1935, pp. 449–456.)

STUDIES IN GROWTH ANALYSIS OF THE COTTON PLANT UNDER IRRIGATION IN THE SUDAN: I. THE EFFECTS OF DIFFERENT COMBINATIONS OF NITROGEN APPLICATIONS AND WATER SUPPLY

By F. CROWTHER (Amm. Bot. [London] 48 (1934), No. 192, pp. 887–913)

Sakellaridis cotton grown at the Gezira Research Farm received light, medium and heavy irrigation and three levels of nitrogen (supplied by ammonium sulphate) in all possible combinations. The morphological and physiological processes resulting in the final crop were studied, and the measurements dealt with rates of change and growth curves rather than crop yield (E. S. R. 68, p. 38.)

Observations on numbers of flowers, numbers of nodes on the remaining stem, and on relative leaf-growth rates demonstrated the function of nitrogen in stimulating meristematic activity. The function of water in extension growth was shown by the internode lengths on the main stem, and it is suggested that its effect on flower numbers is indirect through regulation of extension growth. Net assimilation rate evidently is unaffected by water or nitrogen supply during the main growth phase.

The bolls appeared to exert a dominating effect on the whole plant when their development begins, resulting in the cessation of apical growth of the main stem and in the stoppage of nitrogen uptake from the soil, presumably through the checking of root growth. The nitrogen supply of the plant as a whole is interrupted at the time of the most serious drain on the plants' nitrogen reserved by developing bolls. It is suggested that the cessation of root growth operates through interference with the carbohydrate supply to the roots. The type of interaction between the factors was such that the increase in response to either factor increased with a higher level of the other. The practical importance of the results, particularly as to the necessity of obtaining early favorable growth is stressed. (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, p. 610, U. S. D. A.)

CIGARETTE AND CIGAR TOBACCOS; RELATIONSHIP OF PRODUCTION CONDITIONS TO CHEMICAL AND PHYSICAL CHARACTERISTICS

By W. W. GARNER, C. W. BACON and J. D. BOWLING, Jr. (Indus. and Engin. Chem. 26 (1934) No. 9, pp. 970–974)

The chemical composition and the more important physical properties of flue-cured and Maryland cigarette tobaccos and Connecticut broadleaf binder and Pennsylvania seed leaf filler cigar tobaccos are presented, and their relationship to cultural methods and conditions are considered in this contribution from the U. S. D. A. Bureau of Plant Industry. The data were obtained in part in coöperation with the Maryland and North Carolina Experiment Stations and the North Carolina Department of Agriculture.

The marked difference in quantity of fertilizer nitrogen applied to the cigarette and the cigar types constitutes, according to the data presented, a highly significant factor in the sharp contrasts existing between these two classes of tobacco in the nitrogen-carbohydrate ratio and associated differences in composition of leaf. Certain commercial important distinctions in properties or qualities in the two classes of leaf, including color, elasticity, grain development, aroma, and in part combustibility, are correlated with these differences in chemical composition.

The difference in soil types and details of culture employed in growing the crop are important factors in the less pronounced contrast in properties existing between the cigar binder and cigar filler types, both high nitrogen products. In this instance contrasts in properties are not so clearly reflected in the organic constituents of the leaf, although significant differences exist in the composition of the ash. Both of the cigarette tobaccos have a high content of total carbohydrate, but the reason the Maryland type has an especially high content of pectin and cellulose instead of the high content of sugar and starch found in the flue-cured was not determined, although apparently soil factor is involved. The method of curing commonly used materially influences the chemical and physical characteristics of the flue-cured type. (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, p. 613, United States Department of Agriculture.)

STRUCTURAL RESPONSES TO THE PRACTICE OF TOPPING TOBACCO PLANTS: A STUDY OF CELL SIZE, CELL NUMBER, LEAF SIZE, AND VEINAGE OF LEAVES AT DIFFERENT LEVELS ON THE STALK

By G. S. AVERY, Jr. (Bot. Gaz. 96 [1934], No. 2, pp. 314–329.)

In the tobacco plant vegetative growth usually ceases soon after seeds start to form, but if the terminal flower stalk and all auxillary branches are removed by topping and suckering, respectively, as fast as they appear, the upper few leaves on the stalk continue to enlarge for some time. In a study with several varieties at Connecticut College, actually the upper third of the leaves on the stalk had a prolonged growth period in plants topped at the 21st leaf; and the 17th, 19th and 21st leaves of such plants, compared with corresponding leaves of untopped plants, showed 32 per cent greater average area and 29 per cent greater average thickness. This increased growth of upper leaves of topped plants appeared due to a greater than usual increase in cell size. The palisade and upper and lower epidermal cells averaged 31 per cent larger, whereas the fundamental tissue of the petiole did not increase in proportion to the blade tissues, its cells averaging only 23 per cent larger. The only change in numbers of cells (in leaves 17, 19, 21) due to topping seemed to occur in the vascular tissue. Cambial activity resulted in an average of 47 per cent more liquified zylem elements in the petiolar bundle. Differentiation of secondary pholoem in the petiolar bundles of these leaves was negligible despite cambial activity. In the upper leaves of topped plants fewer secondary pholoem cells were noted in the petiolar bundles than in corresponding leaves of untopped plants. The degree of development of the xylem and the amount of water loss were closely interdependent. See also an earlier note (E. S. R., 70, p. 614.) (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, pp. 613–614, United States Department of Agriculture.

ETHYLENE TREATMENT OF TOBACCO

By U. Rossi (Bol. Tec. [R. 1st. Sper, Coltiv. Tabacchi, Scafati], 30 (1933), No. 4, pp. 221–258; Fr. abs., pp. 257–258.)

Satisfactory results are reported from preliminary experiments wherein green leaves and whole plants and several varieties of tobacco were subjected under certain transformations occurring in the leaves during fire or air curing, and reduced the curing period about 40 per cent. Ethylene seemed to stimulate enzymatic reactions by irritation of cellular plasma without changing the characteristic qualities of the tobacco. Aroma, color and burn were improved, while elasticity was not affected. Ethylene treatment seemed to be useful with tobaccos hard to mature, slow ripening top leaves of certain oriental varieties, and tobacco poor in burn and aroma. (Adapted from Experiment Station Record, Vol. 72, No. 5, May, 1935, p. 614, U. S. D. A.)

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PROGRESS REPORT ON A STUDY OF THE RELATION OF WEATHER CONDITIONS TO THE DEVELOPMENT AND ABUNDANCE OF THE COCONUT LEAF MINER AND ITS PARASITES

By SALUSTIANO S. GONZALES

Of the Division of Plant Pest and Disease Control
Bureau of Plant Industry

Since the coconut leaf miners attracted the attention of people in coconut regions, their apparently sudden appearance in alarming numbers has been the subject of considerable speculation. This pest was first noticed in the latter part of 1929 in San Pablo, Laguna, after which an active campaign against it was started immediately. Within a short time the pest spread to the provinces of Batangas and Tayabas. Judging from its prevalence, it was already present in the groves for some time before its discovery. So far no record can be found of its being so serious and never before had the leaf miner been considered an important and serious pest of the coconut. The campaign against it lasted up to the latter half of 1931, and during all that time various degrees of infestation were recorded. At the end of 1931, although the pest was believed to be under control, a force was still maintained in Laguna to check any possible new outbreak of the pest, or of any other pest or disease. The personnel of the Bureau of Plant Industry in other provinces were also on the lookout for outbreaks in their respective districts.

In February, 1933, a definite program was outlined with the purpose of determining the causes of the recurrence of the pest

in certain parts of the coconut-growing provinces. Research centered in the influence of weather conditions on the abundance of the pest and its parasites. Because of lack of time and shortage of funds, the scope of the investigation was necessarily limited. It is hoped, however, that the data here presented will prove a fair start for future and more extensive work in this direction.

MATERIALS AND METHODS

Seven barrios of San Pablo, Laguna, fairly representative of the different degrees of infestation were selected for this observation. Each barrio was observed for one day of each week so that all of the seven barrios could be covered once every week. The following was the schedule of observations:

Concepcion	Saturdays
Del Remedio	Sundays
San Lucas	Mondays
San Pedro	Tuesdays
Sta. Isabel	Wednesdays
San Jose	Thursdays
San Gabriel	Fridays

Later, however, we found that the infestations in Concepcion, San Lucas, San Pedro, and Sta. Isabel were already negligible; so on April 23, 1934, new barrios which were more heavily infested were selected in their places. These were Sta. Veronica and San Crispin of San Pablo, and San Benito and San Agustin of Alaminos.

Four groves were selected in each barrio at the start and arrangements were made with the grove owners so that leaflets could be taken at random in said groves. Tables 1 and 1-A show the distribution of the groves used in this work. Ten trees were taken up a day from each of the different groves in the assigned barrio and 50 leaflets were, in turn, cut at random from each tree. This gave us a total of 500 leaflets from each grove or 2,000 leaflets from each barrio. For purposes of comparison, we divided the groves into two groups of two groves each. In one group parasites were liberated, while in the other groups no parasites were liberated. For obvious reasons, we made it a point to select groves that are very far apart and the two with the longest distance (about a kilometer) from each other were selected for the liberation of parasites. Hereafter, such groves will be referred to as the treated groves and the ones where no parasites were liberated as the control groves. Each grove con-

TABLE 1.—*Location of groves under study*

Days of examination	Barrios	Groves and owners	Remarks
Saturdays	Concepcion	I Benigno Reyes	Treated.[1]
		II Gil Exconde	Control.[2]
		III Enrique Bautista	Treated.
		IV Pedro Guia	Control.
Sundays	Del Remedio	I Jacinto Nicanor	Treated.
		II Pedro Ciabal	Control.
		III Narciso Gutierrez	Treated.
		IV Eladio Paulino	Control.
Mondays	San Lucas	I Victoria Gutierrez	Treated.
		II Marcos Alcantara	Control.
		III Florentino Mariño	Treated.
		IV Juan Briñas	Control.
Tuesdays	San Pedro	I Santiago Gutierrez	Treated.
		II Narciso Briñas	Control.
		III Juan Gutierrez	Treated.
		IV Lucio Funtanilla	Control.
Wednesdays	Santa Isabel	I Maximo San Pedro	Treated.
		II Raymundo Guia	Control.
		III Fausta Cornista	Treated.
		IV Patricia Reveza	Control.
Thursdays	San Jose	I Lorenzo Alimon	Treated.
		II Arsenio Exconde	Control.
		III Marcial de Luna	Treated.
		IV Marciano Arandia	Control.
Fridays	San Gabriel	I Saturnino Cortez	Treated.
		II Petronilo Fernandez	Control.
		III Juan Cruz	Treated.
		IV Crisanto de los Reyes	Control.

[1] Parasites were liberated in all treated groves.
[2] No parasites were liberated in all control groves.

sisted of at least 500 trees and about 2,000 larval parasites were liberated in each.

These parasites were first collected in test tubes in our laboratory in San Pablo and then liberated in treated groves as mentioned above. Egg parasites were liberated by means of cages. Leaflets with parasitized eggs were placed in these cages which were, in turn, placed in the treated grove. Hence, no actual count of the parasites was made. In spite of any degree of infestation in any or all groves under treatment, such groves were exempt from "las-las" (cutting off the infested leaflets). Hence, throughout this work the selected groves referred to above were never molested by the campaign. Egg parasites were liberated April 1, 1933, and larval parasites, May 6, 1933, when the first signs of larval infestation were noted. We did

TABLE 1-A.—*Location of groves under study*

Days of examination	Barrios	Groves and owners	Remarks
Saturdays	San Crispin	I Potenciano Malvar	Treated.[1]
		II Felipa de Mesa	Control.[2]
		III Zacarias Bondad	Treated.
		IV Consorcia Dichoso	Control.
Sundays	Del Remedio	As in Table 1	
Mondays	San Benito, Alaminos.	I Florencio Cuello	Treated.
		II Potenciano Malvar	Control.
		III Eriberto Reyes	Treated.
		IV Felipe Escueta	Control.
Tuesdays	San Agustin, Alaminos.	I Dionicio Belen	Treated.
		II Esteban Donato	Control.
		III Augusto Reyes	Treated.
		IV Evaristo Tolentino	Control.
Wednesdays	Santa Veronica	I Rufino Alcantara	Treated.
		II Lucas Guevarra	Control.
		III Prudencio Fule	Treated.
		IV Sergio Bonilla	Control.
Thursdays	San Jose	As in Table 1	
Fridays	San Gabriel	As in Table 1	

[1] Parasites were liberated in all treated groves.
[2] No parasites were liberated in all control groves.

not restrict our liberation to only one species of larval parasites, and although our larval parasites were not identified, we suspected that at least four species were used in this observation.

These parasites with which we worked were of the species reared during our first campaign against the pest in 1929 to 1931. The two egg parasites (the yellow species, *Centrodora* sp., Aphelininae and the dark bluish green species, *Achrysocharis promecothecae* Ferriere, Eulophinae, both of the family Eulophidae) were identified by Dr. Leopoldo B. Uichanco, of the College of Agriculture, University of the Philippines, and so with the small and most common species of the larval parasites, these identifications have been verified by Mr. Gahan of the United States Bureau of Entomology and Plant Quarantine. The most common larval parasite was identified as *Pleurotropis* sp., Entedinae, Entedontidae(5). Except for one species of larval parasite, their life histories could not be worked out for our attempts so far to induce these insects to lay eggs in the laboratory failed. Up to the present we know of two species of egg parasites and we have been able to distinguish at least three larval parasites. The bigger species of larval parasites, the life history of which has been already worked out, has been identified by Mr. Gahan as

Sympiesis sp., from specimens sent by the Administration to Dr. Harold Morrison, in charge of the Division of Insect Identification of the U. S. Bureau of Entomology and Plant Quarantine.

Daily temperature and rainfall records were kindly furnished us, upon request, by the San Pablo local observation unit of the Philippine Weather Bureau.

Weekly average infestation of the seven barrios under observation was taken and graphed.

To get the leaflets on time, we employed three laborers (later, these were reduced to two) to go out to the assigned groves and take the needed samples to our laboratory to be examined for eggs, larvæ, pupæ, and adults and for parasitism. For this purpose we employed a worker who had previously served in the campaign, trained in scouting work. The whole project was placed in charge of Mr. Marcos A. Vega, who was given definite instructions as to the object and procedure of the research. Occasionally, as time permitted, we helped in the examination of the leaflets. Mr. Felix D. Lazo, assistant agronomist in San Pablo, also helped a great deal in obtaining the data herein presented. Messrs. Fausto Villanueva and Felix Arriola also rendered valuable assistance in the preparation of the work.

DISCUSSION OF RESULTS

Results of our observations are presented in Tables 2, 2-A, 4, 4-A, 4-B, 4-C, 4-D, and 4-E. Records given in these tables are graphed together with the weather records (Table 3) for the corresponding periods (Charts 1, 2, 3, 4, 5, and 6) to show the relation, if any, between the two.

It can be judged from the graphs of the results so far obtained that, on the whole, there is to be seen some difference in the degrees of infestation between the treated and the control groves, especialy at the beginning of the work. From experience, however, we learned that groves where no parasites were liberated showed high percentages of parasitism sometime after the first days of the invasion by the pest. Even strictly isolated infestations showed signs of parasitism to a certain degree after the pest had persisted there for at least one generation. It is, therefore, evident that parasites are able to follow their host without aid, but such a natural course is so slow that man's help is often necessary to bring about the immediate restoration of the balance between the pest and its parasites, i. e., to bring the pest under control. In the present case, where almost all groves were infested to a greater or less extent and for some

time before the beginning of this work, dispersal of liberated parasites could not be limited only to the groves where they were set free so that, together with the parasites already in the groves, their distribution, at certain times, was almost uniform in the treated and control groves. This was especially true toward the middle and end of the observation period. Some treated groves for some time after the liberation of the parasites, even exceeded the control groves in the degree of infestation and some control groves exceeded the treated groves in parasitism. There is to be noted also a marked decrease in the degree of infestation in the area under observation towards the end of the study. As will be seen elsewhere in this report, more serious infestations were discovered in other parts of Laguna which spread to Tayabas and Batangas, but many such infestations seemed to be independent of the one we had been working on and which was made material for the present study. But there was every indication that the infestation within the area under study showed improvement as we progressed.

Before we go further, let us distinguish between the different broods of the pest within the time limit of the present observation. These are as follows:

First brood—April 21 to June 30	70 days
Second brood—July 1 to September 15	77 days
Third brood—September 16 to December 8	84 days
Fourth brood—December 9 to March 9	90 days
Fifth brood—March 10 to May 11	63 days

As the broods of the pest were overlapping, we were not able to draw a definite demarcation between broods, but the preponderance of new eggs was taken as an indication of the beginning of a new brood.

Tables 2 and 2-A and Chart 1 show that the liberation of egg parasites had a decidedly favorable effect on egg parasitism in a grove. In this stage of the pest, the advantage of parasite liberation is very much in evidence. For the first brood (April 21 to June 30) the average parasitized eggs for every frond in the treated groves was 119.459 as against 86.755 for the control groves. Those in the treated groves represent 19.31 per cent of the total eggs laid during the brood while those in the control represent 14.67 per cent. For the following brood, or 147 days from the start of our study, the corresponding figures were 86.577 and 84.537. They represent 21.84 and 20.14 per cent, respectively, of the total eggs laid in the treated and the

control groves. Whereas the difference in the parasitized eggs between the treated and control groves was 3.64 per cent for the first brood, the corresponding difference in the second brood was only 1.70 per cent. In the third brood, this difference was only 0.40 per cent. The following brood showed a difference of 2.23 per cent in favor of the treated groves but in the fifth brood (March 10 to May 11) the control groves showed greater egg parasitism (by 0.83 per cent). For lack of funds, observations on the sixth brood was not continued, so that we cannot include in the discussion of this report what data we gathered during this period, although there were indications of greater parasitism in the treated groves.

The foregoing results clearly confirm the statement made in the earlier part of this discussion with reference to the increase in parasitism in a grove where no parasites were previously liberated. Let us take the difference between the egg parasitism of the treated and control groves in the first and the second broods (3.64 and 1.70 per cent, respectively). And as we note the differences in the later broods, we find the tendency of parasitism to be the same. Although we are not yet sure as to the exact life history of the egg parasites, we are sure that they can multiply at least 6 times (the average number of parasites found in an egg is 3; and 2 generations of the parasites are possible within the incubation period of the eggs of the pest) before the leaf-miner egg hatches. Now, there are many factors, among them wind and the ability of the parasites themselves to fly far, which aid the parasite to spread. This perhaps accounts for the almost uniform parasitism in the treated and control groves in the succeeding broods of the pest.

With regard to the effect of temperature and relative humidity on egg parasitism, comparison of the egg parasitism mentioned in the preceding paragraph with the average temperature for the brood shows that they are inversely proportional. From the first brood down to the fourth, there was a steady increase in the percentage of parasitism of the egg, while there was a marked decrease in the average temperature. Then, parasitism went down from 36.94 and 34.71 per cent in the treated and control groves, respectively, of the fourth brood, to 22.71 and 23.54 per cent, respectively, of the fifth brood, while the temperature correspondingly rose from 26.12° to 28.78°C. There is also a slight correlation between egg parasitism and relative humidity. As we have no weather records for Decem-

ber for no observations were made in San Pablo during this month, we cannot safely make use of the average weather records in the period covered by our fourth broods, but on the whole, there can be noted a sign of direct correlation between egg parasitism and relative humidity. Table 4 shows a marked rise in egg parasitism from the first brood to the fourth, as well as a rise in relative humidity for the corresponding period. The tendency of parasitism to go down in the fifth brood is accompanied by a corresponding fall in the relative humidity for the same period. In nature, as represented by our control groves, the same tendency was noted.

Several reasons can be advanced to explain this: In the first place, heat directly affects the egg adversely. We dissected numerous eggs in the field with the contents of each crumpled and dried. It seems that high temperature and the accompanying low humidity induce excessive evaporation which proves detrimental to the eggs of the pest, reducing the food supply of the parasite eggs that may have been laid in these leaf-miner eggs. Even if these eggs were not parasitized, their drying due to these factors reduces the number of fresh eggs in a grove which also reduces the chance of the parasites to locate their hosts. Because the parasites feed on moisture on the leaflets or the nectar of the flowers of various plants, and since high temperature and low humidity prevent such accumulation on the leaflets of the coconut, the parasites were forced to leave the palm and to seek for food elsewhere. This may also account for their scarcity in the coconut groves, especially the clean ones, during hot days.

Also, high temperature and low humidity caused the blotch in the leaflet where the egg of the pest was laid, to become hard, so that it was difficult, if not impossible, for the parasite to insert its ovipositor and reach for the egg of the leaf miner. For the same reason, eggs of the parasites which were laid at the time when conditions were favorable, may hatch and reach maturity at a time when the temperature is high and humidity low, so that the leaf tissue immediately above the egg is hard, in which case the parasites died either because of the direct effect of heat or because the hardness of the dried portion of the leaflet rendered it impossible for them to make an exit hole. In this case they were trapped and died of starvation.

The effect of rain on the eggs is not clearly marked, although there is indication that rain tends to reduce the number of egg parasites. Chart 1 shows, in the first three broods of the

pest, the adverse effect of rain on egg parasitism. As the weather record for December was incomplete, that month is not included in our discussion. For the period beginning January 5, 1934, we find the same relation obtaining.

At about the beginning of April (week ending April 14), when the rain was slight (7.6 millimeters), the parasitism of the egg was high (262.688 to the frond for the treated groves and 172.363 to the frond for the control). Through May and June, there was a decided increase in rainfall (49.89 mm. and 20.58 mm. for weeks ending June 23 and 30, respectively), and conversely, the egg parasitism went down (66.306 to the frond for treated and 71.943 to the frond for control, respectively). Towards the end of July and the beginning of August when rainfall was heavy (99.7 millimeters for the week ending August 2), egg parasitism was very low (35.681 to the frond for treated and 25.731 to the frond for control). As the rain decreased by the end of August (44.9 millimeters for the week ending August 25), egg parasitism again increased (138.825 to the frond for treated and 115.812 to the frond for control). Most of the parasites at this time were already in the eggs of the leaf miners, so that intermittent heavy rains of September and October did not materially affect them and examination in the laboratory showed many of the eggs parasitized. Many of the eggs thus examined were attacked by fungus and many of them had dead parasites in them. This interference of the fungus with the proper development of the parasites was largely caused by the rain at about the beginning of October and is reflected in the lower parasitism at about the middle of October. When rain became scarce towards the end of October (13.4 millimeters for the week ending October 27) up to early November (58.9 millimeters for the week ending November 3 and 2.5 millimeters for the week ending November 10), parasitism of the egg again showed a tendency to rise (85.370 to the frond for treated and 84.600 to the frond for control for the week ending October 27; 90.090 to the frond for treated and 87.206 to the frond for control for the week ending November 3; and 107.838 to the frond for treated and 95.044 to the frond for control for the week ending November 10). By November 24, when the precipitation for the week ending on that date was 4.80 millimeters, the numbers of parasitized eggs to the frond were 123.975 for the treated and 135.032 for the control. From January 1 to March 30, 1934, when rainfall ranged from 0 to 24.10 millimeters, the parasitized eggs to the frond ranged from 41.940 to 95.337 for the treated

and from 10.499 to 76.500 for the control. Rainfall after this period up to the end of the present observation (June 29) ranged from 0 to 134.30 millimeters. The number of parasitized eggs to the frond for the corresponding period ranged from 4.680 to 54.090 for the treated and from 3.470 to 51.930 for the control.

Effect of weather conditions on the larvae and their parasites.—As was mentioned before, we liberated more than one species of larval parasites in each treated grove, as was the practice even during our campaign from 1929 to 1931. While the effect of such liberation was visible in the first instar larvæ as shown in Table 4–A, it was not evident in the succeeding instars. Our failure in obtaining the same results in the second and third instars as in the first instar may be explained by the fact that although *Pleurotropis* occasionally succeeded in parasitizing first instar larvæ, none of the progeny reached the adult stage and died with the host. The main reason for the failure of this parasite to multiply when its host is in the first instar is probably because several of such parasites are present in each leaf miner and ordinarily the parasites require more subsistence than can be had in a first-instar larva. Whether the presence of numerous larvae of the parasite in one host is due to the polyembryony of the parasite or to its ability to lay so many eggs at one time is not as yet known. But the fact that there are usually from 2 to 5 such parasites emerging from one host in the second instar and still more from that in the third instar is enough clue that this number of parasites requires more subsistence than can be had in a first-instar larva. It thus seems apparent that the liberation of *Pleurotropis* when the leaf miner is in the first instar is not advisable, unless overlapping generations exist in the groves where these parasites are liberated. On the other hand, the bigger parasite, *Sympiesis* sp., lays but one to four eggs on each leaf miner, and these upon hatching, need no more than what they can consume of their host. However, we cannot consider the other parasites thus liberated to have perished as we have no idea so far as to their life histories and behavior outside the body of the leaf miner. After our liberations, these parasites may have perished of hunger or may have found some alternate hosts (of which we know nothing) where they found subsistence until the desired stage of the leaf miner was reached.

Considering the effect of the different weather conditions on the larvæ and their parasites we noted a direct correlation be-

tween live leaf-miner larvæ and temperature, that is, the higher the temperature, the more live leaf-miner larvæ we found to the frond. During days of lower temperature we noted higher parasitism. Humidity exerted some influence on larval parasitism and its rôle in increasing larval mortality is much in evidence. We found this to be true for all larval instars. High humidity and high precipitation resulted seemingly in high mortality of the larvæ especially the younger ones. The comparative mortality by instars is as follows: for the first brood with 178.20 millimeters precipitation and 77.6 per cent humidity, the dead larvæ to the frond were 2.43 to 4.39 per cent for the first instar, 5.37 to 8.00 per cent for the second instar, and from 9.80 to 10.28 per cent for the third instar. For the next two broods when rainfall was 594.13 millimeters and 440.60 millimeters, respectively, while the humidity was 82.27 per cent and 80.62 per cent, respectively, larval mortality to the frond rose to from 27.58 to 71.30 per cent for the first instar, 2.04 to 62.37 per cent for the second instar, and from [illegible] to 40.38 per cent for the third instar. Younger larvæ were more susceptible to adverse weather conditions than the [illegible]. Many instances were noted in which larval blotches brought to the laboratory or examined directly in the fields were [illegible] wet, and their interiors almost filled with water. First-instar larvæ often succumbed to these conditions while more mature ones were observed to have been able to resist the water in their blotches until the time when this dried out, and [illegible] live normally. Although the weather records for the fourth brood are not complete, they show a very high percentage of mortality in the first-instar larvæ. The precipitation during this brood would probably be higher if complete records were available. At any rate, the same degrees of resistance were exhibited by the different instars. When precipitation and humidity diminished in the fifth brood larval mortality was also reduced. The tendency of these weather factors to rise in the sixth brood caused the larval mortality to mount also, although records in this brood were not complete. Rainfall and humidity had, to a certain extent, direct effect on the mortality of leaf-miner larvæ.

Effect of weather conditions on the pupæ and their parasites.—As far as present observations are concerned, the different weather conditions do not seem to exert much influence upon the pupæ. Table 4-D shows an increase in the percentage of the live pupæ to the frond for both the control and the

treated groves as the observations progressed. The highest percentage of live pupæ was from December, 1933, to the first week of March, 1934. The different weather records for this period, although incomplete, were incidentally lower than the corresponding records for the other broods. Lower temperature and less precipitation associated with high humidity may be favorable to the pupæ of the pest. On the other hand, lower temperature does not seem very favorable to the parasites of the pupæ, which also seemed to prefer lower humidity.

Effect of weather conditions in the adults.—The effect of weather on the adults could not be accurately ascertained in the present study as our operations were restricted to direct field operations where counts of the adults affected by weather could not be had as in the case of the immature stages which were all confined inside the leaflets. The figures in Table 4-E represent adults found inside the blotches when the leaflets were taken from the groves. These figures, meager as they are, tend to show that the adults are, to a certain extent, adversely affected by heat. In the first two and fifth broods which fell in the months with high temperatures (28.83° and 27.59°C., respectively), the percentages of dead adults inside the blotches were much higher (36.49 and 28.51 per cent, 22.51 and 28.05 per cent, and 21.27 and 22.73 per cent) than those in the third and fourth broods (3.18 and 0.40 per cent, and 14.24 and 3.61 per cent) which fell in the months with low temperatures (26.73° and 26.12° C., respectively).

These findings were corroborated by actual field observations. During the days when the beetles were ready to fly, we could find them swarming in open spaces and across fields early in the morning from about 6 A. M. to about 8 A. M. During this period, the atmosphere was cool and the sun's rays not hot. But after 8 A. M., toward noon and early afternoon, we noted no beetles flying in such places. And if close observations are made right on the grasses in these open areas, plenty of adult leaf miners will be found clinging to the blades of those plants. If they are disturbed they readily fall to the ground instead of flying; or, if they fly, they don't fly long. Also, during hot days, one can find dead adults along roads and especially near houses with galvanized iron roofing. Right on the roofs of such houses, plenty of adults were found dead. These were probably overtaken by heat while on flight, became exhausted, and fell there

ıere they were killed by the hot roofs. The same explanation ay hold true for the adults found along roads in towns and in ›en spaces.

Effect of weather conditions on the duration of the broods of the coconut leaf miner.—Tables 4 to 4-E show a decided effect of temperature and relative humidity on the length of each of the five broods embraced by the present study. During the first brood from April 21 to June 30, or a period of 70 days, the average temperature was 28.83°C. and the relative humidity 77.67 per cent. The gradual lowering of the temperature in the next three broods (27.59°, 26.73°, and 26.12°C., respectively) accompanied by high relative humidity (82.27, 80.62, and 84.29 per cent, respectively), resulted in the gradual prolongation of the broods (77 days for the second, 84 days for the third, and 90 days for the fourth). The fifth brood which occurred during the warmer days of 1934 when the average temperature was 28.78°C. and the relative humidity, 78.63 per cent was much shorter than the preceding ones, being only of 63 days duration. The conclusion, therefore, that we can draw from these results, is that the higher the temperature with the accompanying lower humidity the shorter life cycle of the brood.

Economic application of the results.—The fact that the duration of the broods of the leaf miner was inversely proportional to the rise in temperature and directly proportional to relative humidity enables us to predict the duration of future broods, and to adjust our various means of control to destroy as many of the leaf miners as possible within the time limit of the brood. Since the larvæ were most affected by the weather in that the larval stage was longer during cool weather and shorter during hot weather, more labor should be employed and more parasites reared during hot days to keep pace with the development of the pest.

Moreover, since the parasite, *Sympiesis* sp., is most effective for the first instar and *Pleurotropis* during the succeeding instars, we can determine the species of parasite to be liberated at each point in the life cycle of the pest. Also, although they may exist in a given locality, their migration to the adjoining infested groves required considerable time; therefore, man labor should be employed to facilitate their transfer. A laboratory should be established for the study of the rearing and multiplication of the parasites to insure ready supply when the need arises.

SUMMARY AND CONCLUSIONS

1. There is some difference in the degree of infestation between the control and treated groves.

2. The parasites are able to follow their host without man's aid; but such a natural course is so slow that mass liberation is necessary to bring about the speedy restoration of the balance between the pest and its parasites.

3. The duration of the brood is directly proportional to the relative humidity and inversely proportional to temperature.

4. Egg parasitism is inversely proportional to the temperature and directly proportional to the relative humidity.

5. Although rain has no marked direct effect on the eggs, it tends to reduce the number of egg parasites. On the other hand, it had a marked adverse effect on the younger larval instars but none on the older, and on the pupæ.

6. Liberation of *Pleurotropis* when the host is in the first instar does not seem to be advisable except where the broods of the latter overlap. Survival of the parasites in the absence of suitable hosts in a locality has not been worked out.

7. The higher the temperature the more live larvæ were found to the frond and the less larval parasites.

8. High humidity and high precipitation were found detrimental to the first instar larvæ but not to older stages.

9. The higher the temperature with accompanying lower humidity, the shorter the brood.

10. When the temperature is high and relative humidity low, more labor is required and more parasites should be liberated to keep pace with the development of the pest.

TABLE 3.—*Weekly averages of humidity and temperature at San Pablo, Laguna, for 1933 and 1934*

Weeks ending	Average relative humidity	Average temperature	Total rainfall
	Per cent	°*C.*	*mm.*
April 14	60.10	28.38	7.60
April 21	70.36	28.70	1.30
April 28	72.21	29.27	12.70
May 5	75.14	29.20	17.30
May 12	70.14	29.64	4.36
May 19	74.42	29.46	6.19
May 26	74.93	29.13	25.37
June 2	87.75	28.40	15.73
June 9	74.58	29.50	10.74
June 16	83.75	28.90	15.34
June 23	81.10	28.12	49.89
June 30	82.67	26.70	20.58
July 7	80.57	27.60	51.68
July 14	79.10	28.80	26.17
July 21	76.79	28.50	29.19
July 28	83.75	26.83	68.92
August 4	93.60	27.00	99.70
August 11	81.17	27.40	60.20
August 18	79.71	27.30	24.30
August 25	79.86	28.00	44.90
September 1	79.33	27.90	20.00
September 8	84.10	28.30	34.70
September 15	88.00	25.86	196.40
September 22	88.20	26.15	14.00
September 29	81.30	27.36	71.60
October 6	78.50	27.10	95.30
October 13	82.60	25.92	148.30
October 20	75.40	28.22	27.70
October 27	81.10	27.12	13.40
November 3	79.90	26.96	58.90
November 10	76.30	26.10	2.50
November 17	77.80	27.50	2.60
November 24	82.80	25.33	4.80
December 1 (Records up to November 30 only)	82.87	26.26	1.50
January 5 (Records from January 1 to January 5 only).	80.60	26.80	0.00
January 12	80.50	26.80	1.60
January 19	82.00	26.70	8.50
January 26	95.60	23.20	15.10
February 2	87.70	25.50	3.10
February 9	91.80	23.80	2.10
February 16	76.70	24.90	4.30
February 23	87.30	25.40	24.10
March 2	77.90	28.10	4.50
March 9	82.80	27.00	0.50
March 16	79.60	29.30	6.60
March 23	77.90	27.40	3.50
March 30	84.30	30.00	0.00
April 6	81.50	27.60	134.30
April 13	79.00	27.40	33.70
April 20	78.00	28.90	0.00

TABLE 3.—*Weekly averages of humidity and temperature at San Pablo, Laguna, for 1933 and 1934*—Continued

Weeks ending	Average relative humidity	Average temperature	Total rainfall
	Per cent	°*C.*	*mm.*
April 27	75.80	29.50	6.10
May 4	75.40	29.80	0.00
May 11	76.20	29.10	59.10
May 18	81.00	27.80	97.10
May 25	89.40	26.60	55.60
June 1	79.90	29.20	21.00
June 8	81.00	28.40	24.90
June 15	79.90	28.50	27.60
June 22	78.40	28.40	18.80
June 29	81.10	27.50	27.30

TABLE 4.—*Average number of eggs to the frond in relation to weather conditions.*

Broods	Groves	Hatched Number	Hatched Per cent	Fresh Number	Fresh Per cent	Parasitized Number	Parasitized Per cent	Dead Number	Dead Per cent	Temperature	Total precipitation	Number of days of rainfall	Relative humidity
										°C.	mm.		Per cent
First, April 21 to June 30 (70 days).	Treated	57.267 (8.903)	9.26	33.979 (7.696	5.49	119.459 (13.490)	19.31	408.031 (±15.346)	65.94	28.83	178.20	37	77.67
	Control	79.218 (±12.606)	13.40	48.357 (13.935)	8.18	86.755 (±9.254)	14.67	376.904 (±22.616)	63.75				
Second, July 1 to September 15 (77 days).	Treated	58.203 (±9.591)	19.69	43.044 (14.407)	10.86	86.577 (±6.212)	21.84	108.507 (±18.090)	52.61	27.59	594.13	54	82.27
	Control	84.928 (±13.652)	20.23	45.381 (±11.392)	10.81	84.537 (±8.081)	20.14	204.975 (±19.675)	48.82				
Third, September 16 to December 8 (84 days).	Treated	69.896 (±5.173)	20.91	28.106 (±3.770	8.41	117.391 (±4.081)	35.12	118.903 (±7.403)	35.56	26.73	440.60	44	80.62
	Control	65.842 (±5.619)	19.57	24.889 (±3.352)	7.40	116.797 (±4.566)	34.72	128.850 (±4.728)	38.31				
Fourth, December 9 to March 9 (90 days).	Treated	36.083 (±3.494)	17.01	2.807 (±0.600)	1.32	78.365 (±3.878	36.94	78.365 (±6.509)	44.73	[a] 26.12	[a] 63.80	[a] 25	[a] 84.29
	Control	35.007 (±3.170)	17.73	2.209 (±0.506)	1.12	68.524 (±5.329)	34.71	91.691 (±6.340)	46.44				
Fifth, March 10 to May 11 (63 days).	Treated	50.975 (±9.908)	28.54	16.765 (±11.716)	9.39	40.624 (±3.055)	22.71	70.223 (±8.344)	39.36	28.78	243.30	22	78.63
	Control	47.230 (±9.699	29.43	14.091 (±7.278)	8.78	37.778 (±2.860)	23.54	61.401 (±7.685)	38.25				
Sixth, May 12 to June 29 (48 days, incomplete).	Treated	87.737 (±12.330	34.22	11.291 (±6.077	4.40	38.579 (±4.398)	15.05	118.787 (±12.013)	46.33	[b] 28.02	[b] 272.30	[b] 30	[b] 80.90
	Control	86.798 (±11.986)	35.06	10.836 (±5.079)	4.38	37.010 (±4.007	14.95	112.920 (±5.463)	45.62				

[a] No Records for December.

[b] Observations discontinued for lack of fund.

TABLE 4–A.—*Average number of larvae, first instar, to the frond in relation to weather conditions*

Broods	Groves	Alive		Parasitized		Dead		Temperature	Total precipitation	Number of days of rainfall	Relative humidity
		Number	Per cent	Number	Per cent	Number	Per cent				
								°C.	mm.		Per cent
First, April 21 to June 30 (70 days)	Treated	20.215 (±9.551)	97.46	0.022 (±0.011)	0.11	0.504 (±0.115)	2.43	28.83	178.20	37	77.67
	Control	28.160 (±10.718)	95.59	0.006 (±0.027)	0.02	1.292 (±0.519)	4.39				
Second, July 1 to September 15 (77 days)	Treated	14.250 (±4.297)	51.61	2.547 (±1.379)	9.23	10.813 (±3.556)	39.16	27.59	594.13	54	82.27
	Control	27.403 (±2.880)	68.74	1.467 (±0.384)	3.68	10.995 (±2.516)	27.58				
Third, September 16 to December 8 (84 days).	Treated	9.572 (±1.673)	24.54	2.852 (±0.553)	7.31	26.580 (±1.261)	68.15	26.73	440.60	44	80.62
	Control	8.106 (±1.268)	21.81	2.562 (±0.580)	6.89	26.495 (±1.416)	71.30				
Fourth, December 9 to March 9 (90 days).	Treated	3.196 (±0.540)	14.09	2.257 (±0.290)	9.95	17.228 (±1.619)	75.96	[a] 26.12	[a] 63.80	[a] 25	[a] 84.29
	Control	3.421 (±0.567	15.95	2.094 (±0.250)	9.76	15.933 (±1.437)	74.29				
Fifth, March 10 to May 11 (63 days)	Treated	15.120 (±5.133)	49.23	1.882 (±0.331)	6.14	13.710 (±1.626)	44.63	28.78	243.30	22	78.63
	Control	19.098 (±5.841)	54.85	1.504 (±0.310)	4.32	14.215 (±2.030)	40.83				
Sixth, May 12 to June 29 (48 days, incomplete).	Treated	0.844 (±0.357)	2.73	1.645 (±0.250)	5.33	28.432 (±3.319)	91.94	[b] 28.02	[b] 272.30	[b] 30	[b] 80.90
	Control	1.102 (±0.398)	3.55	1.956 (±0.297)	6.30	28.007 (±3.420)	90.15				

[a] No records for December.

[b] Observations discontinued for lack of fund.

TABLE 4–B.—*Average number of larvae, second instar, to the frond in relation to weather conditions*

Broods	Groves	Alive Number	Alive Per cent	Parasitized Number	Parasitized Per cent	Dead Number	Dead Per cent	Temperature	Total precipitation	Number of days of rainfall	Relative humidity
								°C.	mm.		Per cent
First, April 21 to June 30 (70 days)	Treated	13.120 (±3.669)	91.37	0.082 (±0.020)	0.57	1.158 (±0.344)	8.06	28.83	178.20	37	77.67
	Control	19.941 (±6.509)	92.20	0.526 (±0.304)	2.43	1.160 (±0.378)	5.37				
Second, July 1 to September 15 (77 days).	Treated	9.733 (±2.779)	80.13	0.371 (±0.088)	0.37	2.042 (±0.546)	2.04	27.59	594.13	54	82.27
	Control	13.523 (±3.548)	79.81	0.383 (±0.108)	2.26	3.039 (±0.782)	17.93				
Third, September 16 to December 8 (84 days).	Treated	6.647 (±1.754)	47.56	0.521 (±0.094)	3.72	6.808 (±0.938)	48.72	26.73	440.60	44	80.62
	Control	4.157 (±0.836)	34.91	0.324 (±0.047)	2.72	7.428 (±1.416)	62.37				
Fourth, December 9 to March 9 (90 days).	Treated	3.185 (±0.614)	45.44	0.175 (±0.034)	2.50	3.649 (±0.573)	52.06	[a] 26.12	[a] 63.80	[a] 25	[a] 84.29
	Control	3.097 (±0.567)	45.54	0.198 (±0.040)	2.91	3.505 (±0.526)	51.55				
Fifth, March 10 to May 11 (63 days)	Treated	8.908 (±3.973)	77.01	0.257 (±0.074)	2.22	2.402 (±0.465)	20.77	28.78	243.30	22	78.63
	Control	7.946 (±3.757)	80.17	0.286 (±0.061)	2.88	1.680 (±0.290)	16.95				
Sixth, May 12 to June 29 (48 days, incomplete).	Treated	12.917 (±6.441	61.23	0.394 (±0.088)	1.87	7.784 (±1.275)	36.90	[b] 28.02	[b] 272.30	[b] 30	[b] 80.90
	Control	14.075 (±3.062)	61.38	0.390 (±0.061)	1.70	8.465 (±1.334)	36.92				

[a] No weather records for December.

[b] Observations discontinued for lack of fund.

TABLE 4-C.—*Average number of larvæ, third instar, to the frond in relation to weather conditions*

Broods	Groves	Alive		Parasitized		Dead		Temperature	Total precipitation	Number of days of rainfall	Relative humidity
		Number	Per cent	Number	Per cent	Number	Per cent				
								°C.	mm.		Per cent
First, April 21 to June 30 (70 days)	Treated	12.703 (±4.425)	88.45	0.183 (±0.034)	1.27	1.476 (±0.594)	10.28	28.83	178.20	37	77.67
	Control	14.320 (±5.234)	88.80	0.221 (±0.054)	1.37	1.585 (±0.600)	9.80				
Second, July 1 to September 15 (77 days).	Treated	9.115 (±2.725)	76.94	0.100 (±0.027)	0.84	2.632 (±1.086)	22.22	27.59	594.13	54	82.27
	Control	11.280 (±2.941)	82.05	0.170 (±0.047)	1.23	2.299 (±0.573)	16.72				
Third, September 16 to December 8 (84 days).	Treated	5.599 (±1.889)	65.26	0.251 (±0.047)	2.93	2.729 (±1.018)	31.81	26.73	440.60	44	80.62
	Control	4.734 (±0.580)	58.57	0.085 (±0.013)	1.05	3.264 (±0.911)	40.38				
Fourth, December 9 to March 9 (90 days).	Treated	3.338 (±1.228)	68.68	0.044 (±0.010)	0.92	1.408 (±0.331)	29.39	[a] 26.12	[a] 63.80	[a] 25	[a] 84.29
	Control	2.858 (±0.526)	65.54	0.025 (±0.007)	0.57	1.901 (±0.391)	33.89				
Fifth, March 10 to May 11 (63 days)	Treated	2.352 (±0.742)	79.14	0.049 (±0.010)	1.65	0.571 (±0.182)	19.21	28.78	243.30	22	78.63
	Control	1.212 (±0.398)	69.94	0.014 (±0.005)	0.81	0.507 (±0.486)	29.25				
Sixth, May 12 to June 29 (48 days, incomplete).	Treated	27.385 (±7.932)	88.51	0.018 (±0.010)	0.06	3.537 (±0.816)	11.43	[b] 28.02	[b] 272.30	[b] 30	[b] 80.90
	Control	24.060 (±7.285)	88.25	0.064 (±0.155)	0.23	3.141 (±0.594)	11.52				

[a] No records for December.

[b] Observations discontinued for lack of fund.

TABLE 4–D.—*Average number of pupæ to the frond in relation to weather conditions*

Broods	Groves	Alive Number	Alive Per cent	Parasitized Number	Parasitized Per cent	Dead Number	Dead Per cent	Temperature	Total precipitation	Number of days of rainfall	Relative humidity
								°C.	mm.		Per cent
First, April 21 to June 30 (70 days)	Treated	4.439 (±1.612)	68.61	0.228 (±0.067)	3.52	1.803 (±0.558)	27.87	28.83	178.20	37	77.67
	Control	6.816 (±2.718)	65.27	0.942 (±0.351)	9.02	2.685 (±0.857)	25.71				
Second, July 1 to September 15 (77 days).	Treated	5.046 (±1.376)	79.02	0.110 (±0.027)	1.72	1.230 (±0.425)	19.26	27.59	594.13	54	82.27
	Control	9.717 (±3.076)	82.06	0.089 (±0.020)	0.75	2.035 (±0.722)	17.19				
Third, September 16 to December 8 (84 days).	Treated	7.426 (±2.705)	85.68	0.040 (±0.018)	0.46	1.201 (±0.486)	13.86	26.73	440.60	44	80.62
	Control	6.215 (±2.071)	82.60	0.028 (±0.011)	0.37	1.281 (±0.627	17.03				
Fourth, December 9 to March 9 (90 days).	Treated	1.825 (±0.499)	92.03	0.010 (±0.005)	0.50	0.148 (±0.047)	7.47	[a] 26.12	[a] 63.80	[a] 25	[a] 84.29
	Control	2.011 (±0.634)	92.29	0.005 (±0.003)	0.23	0.163 (±0.040)	7.48				
Fifth, March 10 to May 11 (63 days)	Treated	2.034 (±0.506)	91.91	0.029 (±0.020)	1.31	0.150 (±0.101)	6.78	28.78	243.30	22	78.63
	Control	1.476 (±0.411)	89.67	0 (±0)	0	0.160 (±0.074)	10.33				
Sixth, May 12 to June 29 (48 days, incomplete)	Treated	5.610 (±1.976)	89.18	0.004 (±0.003)	0.06	0.677 (±0.290)	10.76	[b] 28.02	[b] 272.70	[b] 30	[b] 80.90
	Control	5.214 (±1.740)	90.63	0 (±0)	0	0.539 (±0.755)	9.37				

[a] No records for December. [b] Observations discontinued for lack of fund.

TABLE. 4–E.—*Average number of adults of the frond in relation to weather conditions*

Broods	Groves	Alive: Number	Alive: Per cent	Dead: Number	Dead: Per cent	Temperature	Total precipitation	Number of days of rainfall	Relative humidity
						°C.	mm.		Per cent
First, April 21 to June 30 (70 days)	Treated	1.356 (±0.533)	63.51	0.779 (±0.236)	36.49	28.83	178.20	37	77.67
	Control	2.006 (±0.897)	71.49	0.800 (±0.270)	28.51				
Second, July 1 to September 15 (77 days)	Treated	1.491 (±0.553)	77.49	0.433 (±0.169)	22.51	27.59	594.13	54	82.27
	Control	1.803 (±0.782)	73.95	0.635 (±0.236)	26.05				
Third, September 16 to December 8 (84 days)	Treated	1.299 (±0.332)	96.82	0.029 (±0.015)	3.18	26.73	440.60	44	80.62
	Control	1.480 (±0.600	99.60	0.006 (±0.003)	0.40				
Fourth, December 9 to March 9 (90 days)	Treated	0.283 (±0.128	85.67	0.047 (±0.138)	14.24	[a] 26.12	[a] 63.80	[a] 25	[a] 84.29
	Control	0.187 (±0.216	96.39	0.007 (±0.001)	3.61				
Fifth, March 10 to May 11 (63 days)	Treated	0.211 (±0.128)	78.73	0.057 (±0.031)	21.27	28.78	243.30	22	78.63
	Control	0.136 (±0.061)	77.27	0.040 (+0.027)	22.73				
Sixth, May 12 to June 29 (48 days, incomplete)	Treated	1.880 (±0.877)	96.71	0.064 (±0.029)	3.29	[b] 28.02	[b] 272.30	[b] 30	[b] 80.90
	Control	2.113 (±1.025)	94.46	0.124 (±0.054)	5.54				

[a] No records for December.

[b] Observations discontinued for lack of fund.

STUDIES ON THE *SCLEROTIUM ROLFSII* SACC. ATTACKING TOMATO, PEANUTS, AND OTHER PLANTS IN THE PHILIPPINES [1]

By T. G. FAJARDO
Of the Bureau of Plant Industry
and
JOSE M. MENDOZA
Of the Bureau of Science

TWELVE PLATES AND TWO TEXT FIGURES

INTRODUCTION

The tomato, *Lycopersicum esculentum* Mill. and the peanut, *Arachis hypogaea* Linn. are some of the many economic plants of the Philippines often attacked by the well-known soil fungus, *Sclerotium rolfsii* Sacc. In the United States, especially in the southern part, the fungus has been reported causing serious damage on various economic, ornamental, and wild plants (2–7, 10, 12, 13, 15, 17–18). Recently, Weber (18) reported it severe on carrots in Florida and listed all known plants affected by it.

In the Philippines, this fungus is also a problem of no less importance in certain localities, and has been reported attacking various economic plants by Reinking (14), Atienza (1), Ocfemia (11), Fajardo (4), and others. In a survey made by the senior writer in certain provinces of Luzon Island, tomatoes, peanuts, or beans showed from a trace to 50 per cent infection in the field. In certain farms in Maraboc, Manaoag, Pangasinan Province, from 20 to 50 per cent of bearing tomato plants were infected or dead because of it, while in Binalonan and Umingan of the same province infection on tomato, peanuts, and eggplants in the field varied from 5 to 20 per cent. The fungus was also noted on various garden plants in the school gardens at San Carlos Farm School, Pangasinan Province; at Paniqui, and Moncada, Tarlac Province; at Central Luzon Agricultural

[1] This investigation was started in the Bureau of Science and continued in the Bureau of Plant Industry when the senior writer was transferred to the latter Bureau in 1933.

School, Muñoz, Nueva Ecija Province; and at Batac Farm School, Batac, Ilocos Norte Province. In the Trinidad Agricultural School, La Trinidad, Mountain Province, potatoes, tomatoes, cabbages, or beans, and other ornamental plants (4) are generally attacked.

In the Provinces of Laguna, Batangas, Rizal, Bulacan, and Bataan this fungus is also common in tomato, peanut, sweet potato, pineapple, or yautia plants (*Xanthosoma sagittifolium* Schott). In Los Baños and in Lilio, Laguna; Lipa and Balayan, Batangas; Pasig, Rizal; Calumpit, Bulacan; and Balanga, Bataan, it is generally noted in tomato and peanut plants. In some Chinese and other home gardens in Manila, peanuts, sweet potatoes, eggplants, peppers, and some ornamental plants may be found generally affected. In the markets of Manila, it may be found affecting gabi corms (*Colocasia antiquorum* Schott) and other vegetables. While this survey is limited in its scope, it is believed that, because of the generally warm climate of these Islands, the *S. rolfsii* Sacc. might be more widely distributed and dangerous to crops than here reported.

Since this fungus is known to attack many agricultural plants, (18) which are or can be also grown in the Philippines, and since the climate of the Philippines is generally warm for its continued activity, its economic importance can not, therefore, be overemphasized. A study on certain phases of cultural and biologic behavior of the fungus will be of great interest, and this paper presents the results so far obtained.

SYMPTOMS OF TOMATO PLANTS AFFECTED BY *S. ROLFSII*

The symptoms of various plants affected by *S. rolfsii* have already been described by other workers. A brief description of the symptoms on tomato, however, will be presented, since this is one of the important field fruit crops commonly affected by it in the Philippines.

The tomato is susceptible at any stage of growth and on any part of the plant which comes in contact with the soil. Young plants, however, are more susceptible and rapidly killed than full grown plants with woody stems; and mature plants which shade their stems are more apt to be infected than those which allow sunshine and circulation of air more freely. In the seedbed where the seedlings are very close together, the fungus spreads very fast, and causes them to "damp-off" rapidly, while

in the field this situation is not generally met. The lesion first shows water-soaked appearance but as the disease progresses. the tissues rot or collapse rapidly. When the main stem is infected it is girdled, or gets rotted, and the whole plant, irrespective of its stage of maturity, gradually dies within a few days. Where infection is on the leaves, fruits, or branches, only these parts will rot or die without necessarily killing the whole plant.

A plant once infected seldom, if ever, recovers from the disease. When the weather is hot and dry the disease progresses slowly, and the whole plant may produce fairly good crop during the season. If, at any time during the season, the weather becomes warm, moist, or rainy, and there is abundant moisture in the soil, the fungus again becomes active, and the infected plant sooner or later dies without bearing any fruit. When such an infected or dead plant is pulled up the stem just below the soil line will show the diseased tissues with varying degrees of rotting. On these tissues and on the surrounding soil are strands of white, thick mycelia or the small, circular light brown to brown sclerotia of the fungus, characteristic of the disease. (Plate 1, figs. 1, 2, 3, and 5.)

The symptom on the fruit is a typical rot. Fruits which come in contact with the soil or those kept in storage under moist and warm conditions are generally attacked. The lesions show water-soaked appearance, but as the disease progresses, the characteristic rot will develop, until the whole fruit is completely involved. From this rotted fruit, the characteristic mycelia or sclerotia of the fungus are also found. (Plate 1, fig. 4).

ISOLATION OF *S. ROLFSII* SACC.

S. rolfsii can be readily isolated in pure culture on any of the standard culture media, either by placing bits of previously surface sterilized infected tissues, by direct transfer of mycelia or sclerotia, or by first placing infected tissues on moist petri dishes at room temperature 28–32°C. and the aërial mycelia or sclerotia which develops after 2 to 4 days can be transferred directly with sterile forceps or needle into poured agar plates. (Plate 2.) The fungus in pure culture then after 2 to 3 days will produce aërial, cottony, white, rather coarse flocculent septate mycelia, and afterwards its numerous light brown to dark brown sclerotia measuring from 0.5 to 1.2 mm. or more in size are developed.

Using one of the methods mentioned above, *S. rolfsii* [2] from certain regions of the Island of Luzon were isolated and were studied as will be discussed below. For convenience, each isolation is referred to as "strain." Strain I is isolated from tomato from Binalonan, Pangasinan; Strain II, isolated from tomato from Sta. Cruz, Laguna; Strain III, isolated from peanut from Los Baños, Laguna; Strain IV, isolated from beans from Trinidad Valley, Mountain Province; Strain V, isolated from pineapple from Calawang, Laguna; Strain VI, isolated from peanut from San Carlos, Pangasinan; Strain VII, isolated from peanut from Batac, Ilocos Norte; and Strain VIII, an undetermined sclerotium-like fungus isolated from infected peanut from Lilio, Laguna. Various isolations of the fungus were also made from other regions of Luzon Island, but as they appeared identical to some of those mentioned above, they are omitted in the following studies.

PATHOGENICITY TESTS OF VARIOUS STRAINS

In series of infection experiments, the eight "strains" or isolations of *S. rolfsii* were found all pathogenic and cause infection or death on susceptible plants without intervention of wounds. Tomato, peanut, bean, pea, potato, squash, tobacco, corn, and ampalaya (*Momordica charantia*) plants growing in 8–inch flower pots were inoculated by placing near normal and wounded stem bits of mycelia from 3 days old colony of each strain. The plants were then kept moist on one side of the bench in the greenhouse. After 3 to 8 days or more the plants were already infected or dead depending upon the stage of maturity and succulence of the inoculated plants. On young tomato, potato, squash, pea, ampalaya and bean plants with succulent stem, infection and death were observed within 2 to 4 days; on peanuts and tobacco plants, because of their more woody stems, infection and death were delayed; and on corn, infection was limited to the leaf-sheat and none was killed after the end of the experiment.

These results were further confirmed when tomato, potato, and bean plants were planted in inoculated soil put in cylinders. Again these plants died within a few days showing that all are pathogenic and that these economic plants are equally susceptible to anyone of these "strains" or isolations of *S. rolfsii*.

[2] Some of the isolations are identical to the authentic culture of *S. rolfsii* from the University of Wisconsin and from the Florida Experiment Station. No doubt we have here in the Philippines the *S. rolfsii* fungus.

(Plate 3.) In this connection, sclerotia were produced by each strain on the infected region and on the neighboring soil. Strains I to VI, generally produced round to ovoid, light brown to dark brown sclerotia, ranging in size from 0.4 mm. to 1.0 mm. or more, Strain VII, produced ovoid, oblong to irregular, light brown to brown sclerotia, ranging in size from 0.4 mm. to 1.5 mm. or more, and Strain VIII produced pale pink to pink, ovoid, oblong to heart or top shape sclerotia, ranging from 0.5 mm. to 2.0 mm. or more in diameter. Using the sclerotia as a source of reisolation, the strains were again isolated in pure culture.

CULTURAL STUDIES OF VARIOUS "STRAINS"

The rate of growth on different culture media.—The various strains differ in their rate of growth when grown on various culture media. In the first series, four 9-cm. plates each containing 10 cc. of potato agar, malt agar, oatmeal agar, peanut agar, and cornmeal agar were inoculated with 3 mm. mycelial blocks from 4 days old colony of each strain. The plates were then incubated at 28–32°C. and the diametric growth were measured after 3 days. From Table 1 it will be seen that Strains I to VI showed more rapid growth than Strain VII and Strain VIII on all the media tested. Strains I to VI on potato agar, malt agar, oatmeal agar, and peanut agar covered the 9-cm. plates within 3 to 4 days, while Strain VII and Strain VIII failed to cover it even after 5 days when the final notes were made. On cornmeal agar, all the strains started to grow slowly, but, again the last two strains showed slower growth.

TABLE 1.—*The rate of growth of various S. rolfsii "strains" on different media*

Srains of *S. rolfsii*	Average growth after 3 days on various culture media				
	Potato agar	Malt agar	Oatmeal agar	Peanut agar	Cornmeal agar
	cm.	*cm.*	*cm.*	*cm.*	*cm.*
I	9.0	8.5	8.7	7.7	5.7
II	9.0	9.0	8.2	8.5	6.1
III	9.0	9.0	8.1	8.4	6.3
IV	8.5	8.6	9.0	7.1	5.3
V	8.7	8.5	9.0	7.9	6.4
VI	8.0	8.7	9.0	8.7	6.6
VII	7.4	6.1	6.8	6.1	5.3
VIII	7.5	8.3	5.4	6.7	5.0

The result above was confirmed in another trial where steamed rice, steamed cornmeal, and steamed oatmeal were also used in addition to the five media mentioned above. In Fig. 1 is a graph representing the average growth of each strain after 3 days. On

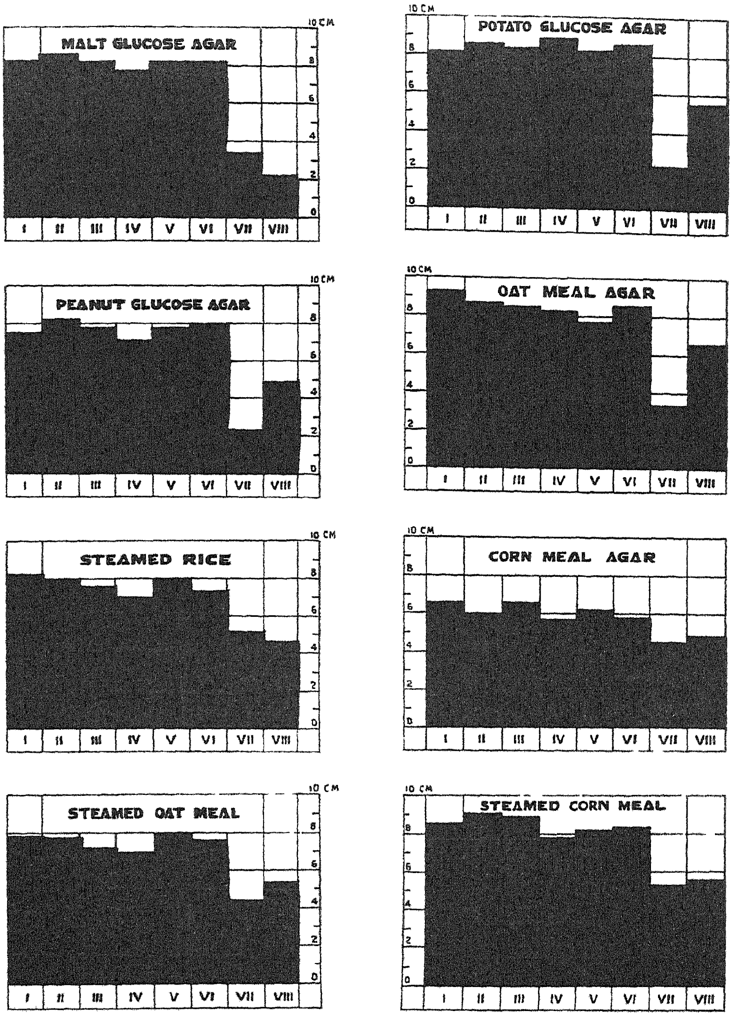

FIG. 1. The rate of growth of various strains on different culture media after 3 days at 28–30° C

potato agar Strains I to VI made an average growth ranging from 8.1 to 8.8 cm *on malt agar* from 7.7 to 8.6 cm; *on oatmeal agar* from 7.8 to 9.3 cm; *on peanut agar* from 7.1 to 8.2 cm; *on*

[8]Five grams of each material and 10 cc. of water were placed to each petri dish and autoclaved at 20 lbs. pressure for 30 minutes.

cornmeal agar from 5.7 to 6.6 cm; *on steamed rice* from 7.0 to 8.3 cm; *on steamed cornmeal* from 7.8 to 8.9 cm; and *on steamed oatmeal* from 7.0 to 7.9 cm., respectively. Strain VII and Strain VIII, on the other hand made, respectively, an average growth of 2.2 and 5.5 cm. *on potato agar;* 3.4 and 2.4 cm. *on malt agar;* 3.4 and 6.6 cm. *on oatmeal agar;* 2.3 and 4.9 cm. *on peanut agar;* 4.5 and 4.9 cm. *on cornmeal agar;* 5.1 and 4.6 cm. *on steamed rice;* 5.3 and 5.6 cm. *on steamed cornmeal;* and 4.4 cm. and 5.4 cm. *on steamed oatmeal.*

In this connection, slight differences were noted in the density and type of colony produced by each strain. The relative density of growth of various strains as shown in Table 2 indicates that the best media for all the strains are steamed rice, steamed cornmeal, steamed oatmeal, and then followed by cornmeal agar, potato agar, peanut agar, malt agar, and oatmeal agar. The type of colony produced on these media varied slightly. When

TABLE 2.—*Density of mycelia produced on various culture media by S. rolfsii "strains" incubated at 28–32° C.*

Media used	*Sclerotium rolfsii* isolations [a]							
	I	II	III	IV	V	VI	VII	VIII
Potato agar	+++	+++	+++	+++	+++	+++	+++	++
Malt agar	++	++	++	++	++	++	++	++
Oatmeal agar	+	+	+	+	+	+	+	+
Peanut agar	++	++	++	++	++	++	++	++
Cornmeal agar	+++	+++	+++	+++	+++	+++	+++	+++
Steamed rice	++++	++++	++++	++++	++++	++++	++++	++++
Steamed cornmeal	++++	++++	++++	++++	++++	++++	++++	++++
Steamed oatmeal	++++	++++	++++	++++	++++	++++	++++	++++

[a] The symbols represent the density of mycelial growth. + poor to slight mycelial growth; ++ good mycelial growth; +++ very good mycelial growth; ++++ excellent mycelial growth.

the colonies are young, Strains I to VI on potato agar, malt agar, oatmeal agar, peanut agar, and cornmeal agar may produce colonies which are aërial to subaërial, fluffy to cottony, thick or thin colonies depending upon the media, while both Strains VII and VIII produced much coarser, fluffier, and thicker colonies. (Plate 4.) However, when the colonies becomes older some variations were noted. Strain VII become matted as Strains I to VI, but on the colony, thick or dense masses of mycelia are found from which the sclerotia may be produced. Strain VIII, on the other hand, besides producing aërial thready to cobwebby

The sizes of sclerotia produced.—The size of sclerotia produced also varies with the different strains. For this study, sample of air dry sclerotia of each strain produced at 28–32° C. from the experiments above were measured with a Vernier caliper.

As shown on Table 4 Strains I to VI on potato agar produced sclerotia ranging from .3 to 2.2 mm., mode of .8 to 1.0 mm., while Strain VII the sclerotia are from .5 to 2.2 mm., mode of 1.2 mm.; on malt agar the sclerotia of Strains I to VI ranges from .4 to 1.8 mm., mode of .8 to 1.0 mm., while Strain VII the sclerotia are from .6 to 4.2 mm., mode of 1.2 mm on oatmeal agar the sclerotia of Strains I to VI ranges from .4 to 1.7 mm., mode of .7 to 1.0 mm., while Strain VII the sclerotia ranges from .5

TABLE 4.—*The relative sizes of sclerotia produced by various "strains" of S. rolfsii.*

Media used		Sizes of sclerotia of various "strains"							
		I	II	III	IV	V	VI	VII	VIII
		mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Potato agar	Range	0.4–1.8	0.4–1.6	0.4–2.0	0.3–2.2	0.4–1.5	0.6–1.4	0.5–2.2	....
	Mode	0.9	0.8	0.9	1.0	1.0	0.8	1.2	
Malt agar	Range	0.4–1.8	0.4–1.4	0.5–1.5	0.4–1.3	0.4–1.3	0.4–1.3	0.6–4.2	[a]3.0–5.0
	Mode	0.8	0.9	1.0	0.8	0.9	0.8	1.2	
Oatmeal agar	Range	0.5–1.7	0.5–1.6	0.5–1.5	0.5–1.6	0.4–1.4	0.5–1.4	0.5–3.2	....
	Mode	1.0	1.0	1.0	1.0	1.0	0.7	1.2	
Peanut agar	Range	0.4–1.3	0.5–1.2	0.5–1.4	0.5–1.3	0.5–1.4	0.5–1.2	0.8–3.7	....
	Mode	0.8	0.8	0.8	0.8	0.9	0.8	1.2	
Cornmeal agar	Range	0.5–2.2	0.4–2.7	0.4–1.9	0.8–3.5	0.6–2.2	0.4–2.2	0.8–3.9	....
	Mode	1.0	1.0	1.0	1.2	1.2	1.0	1.3	
Steamed cornmeal	Range	0.5–2.5	0.5–2.0	0.4–1.3	0.5–1.9	0.5–2.2	0.4–2.8	1.3–5.3	
	Mode	1.0	1.0	0.8	1.0	1.1	1.0	2.1	
Steamed rice	Range	0.6–2.2	0.8–2.7	0.7–2.5	0.5–2.3	0.7–2.7	0.6–1.4	0.6–5.4	
	Mode	1.0	1.0	1.0	1.0	1.0	1.0	1.5	

[a] Range of size of 5 sclerotia produced from 4 plates.

to 3.2 mm., mode of 1.2 mm.; on peanut agar the sclerotia of Strains I to VI ranges from .4 to 1.4 mm., mode .8 to .9 mm., while Strain VII the sclerotia ranges .8 to 3.7 mm., mode of 1.2 mm.; on cornmeal agar the sclerotia of Strains I to VI ranges from .4 to 3.5 mm., mode 1.0 to 1.2 mm., while Strain VII the sclerotia ranges from .8 to 3.9 mm., mode of 1.3 mm.; on steamed cornmeal the sclerotia of Strains I to VI ranges from .4 to 2.8 mm., mode .8 to 1.1 mm., while Strain VII the sclerotia ranges from 1.3 to 5.3 mm., mode of 2.1 mm.; on steamed rice the sclerotia of Strains I to VI ranges from .5 to 2.7 mm., mode 1.0 mm., while Strain VII the sclerotia ranges from 0.6 to 5.4 mm.,

mode of 1.5 mm. Strain VIII did not usually produce sclerotia but those five sclerotia produced from 2 plates on malt agar varies in size from 3.0 mm. to 5.0 mm.

From these results it will be seen that Strain VII produced a wider range and bigger mode size of sclerotia than Strains I to VI. On media rich in carbohydrates, i. e., steamed cornmeal, steamed rice, and steamed oatmeal the range in size of sclerotia of Strains I to VI were increased but they did not equal the sclerotia of Strain VII on same media. Plate 9 shows the sizes of sclerotia of Strains I, III, IV, VI, and VII on potato agar. On potato agar and malt agar, Strain VII showed a model size difference from Strains I to VI of 0.2 to .4 mm., on oatmeal from 0.2 to .5 mm., on peanut agar from 0.3 to .4 mm., on corn meal agar from .1 to .3 mm., on steamed cornmeal from 1.0 to 1.3 mm., and on steamed rice 0.5 mm. With the limited sclerotia produced by Strain VIII, this strain produced bigger sclerotia than Strains I to VI, and on malt agar, its sclerotia is bigger than Strain VII.

In this study, distinct differences were noted on the shape and other characteristics of the sclerotia. The sclerotia of Strains I to VI on potato agar, malt agar, oatmeal agar, and peanut agar are generally small, spherical, ovoid to irregular shape, but when grown on media rich in carbohydrates, i. e., steamed rice, steamed oatmeal, and steamed cornmeal the sclerotia may become ovoid to irregular shape, and may attain bigger sizes due to coalescence of two or more sclerotia. On such big irregular sclerotia, pits may be very evident. The sclerotia of Strain VII on any of these media are generally big, ovoid to irregular, and when the sclerotia coalesce they may attain various shapes from irregularly branched, kidney to sausage-shaped. (Plate 9, fig. 2.) The sclerotia of this strain are generally pitted but with the smaller ones, pits are less evident. With Strain VIII when its sclerotia are produced, they are either round, ovoid, irregular, heart to top-shaped and may also become pitted.

The color[5] *of the sclerotia.*—The color of sclerotia of various strains showed slight differences even when grown on different or on the same media. As shown on Table 5 of the sclerotia of Strains I, II, III, and VI on potato agar have generally snuff

[5] The color nomenclature is based from Ridgway's Color Standards and Color Nomenclature. 43 p., 53 colored pl., 1115 named colors. Washington, D. C. 1912.

296570——3

TABLE 5.—*Comparison on the color of sclerotia produced by each S. rolfsii "strains."*

Media used	Color[a] of sclerotia of *S. rolfsii* "strains"							
	I	II	III	IV	V	VI	VII	VIII
Potato agar	Clay to snuff brown.	Clay to snuff brown.	Sayal brown to snuff brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Sayal brown to snuff brown.	Snuff brown to verona brown.	----------
Malt agar	Clay to sayal brown.	Sayal brown to snuff brown.	Clay to sayal brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Sayal brown to snuff brown.	Sayal brown to snuff brown.	Pale pink to pinkish color.
Oatmeal agar	Sayal brown to snuff brown.	Sayal brown to snuff brown.	Sayal brown to snuff brown.	Snuff brown to verona brown.	Verona brown to sepia.	Snuff brown to verona brown.	Snuff brown to verona brown.	----------
Peanut agar	Clay to sayal brown.	Clay to sayal brown.	Clay sayal to brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	----------
Cornmeal agar	Light clay to snuff brown.	Light clay to snuff brown.	Light clay to snuff brown.	Snuff brown to verona brown.	Sayal brown to verona brown.	Sayal brown to verona brown.	Snuff brown to verona brown.	----------
Steamed rice	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Sayal brown to snuff brown.	Snuff brown to verona brown.	----------
Steamed corn-meal.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	Snuff brown to verona brown.	----------

[a] From Ridgway's *Color Standards and Color Nomenclature.* 43 pp., 53 colored pl., 1115 named colors. Washington, D. C. 1912.

brown, while Strains IV, V, and VII have generally verona brown. On malt agar, Strains I and III have generally sayal brown; Strains II, VI, and VII generally snuff brown; and Strains IV and V generally verona brown. On oatmeal agar Strains I, II, and III have generally snuff brown; Strains IV, VI, and VII generally verona brown and Strain V generally sepia. On peanut agar Strains I, II, and III have generally sayal brown and Strains IV, V, VI, and VII generally verona brown. On corn meal agar, Strains I, II, and III have generally snuff brown and Strains IV, V, VI, and VII generally verona brown. On steamed rice, steamed cornmeal or on steamed oatmeal all the strains produced generally verona brown sclerotia.

From this result the color differences of sclerotia are not so marked to be significant in distinguishing one strain from another. In general, however, Strains I, II, III, and VI produced much lighter brown sclerotia on potato agar, malt agar, peanut agar, and cornmeal agar, and Strains IV, V, and VII produced slightly darker brown sclerotia on this media, but on media rich in carbohydrates Strains I to VII all produced identical color of sclerotia. Strain VIII differed from the rest of the strains in producing pale pink to pinkish color sclerotia as mentioned above.

Effect of temperature on rate of growth and formation of sclerotia.—Temperature affects the rate of growth, type of colony, and in time of formation of sclerotia of the various strains. In a series of studies, four plates containing 10 cc. potato agar for each range of temperature were inoculated with 3 mm. mycelial blocks of each strain. The plates were then incubated at the Bureau of Science with temperatures ranging from 6–8°C., 13–15°C., 18–20°C., 28–30°C., 33–35°C., and 43–45°C., and the average growth of each strain were made after 2, 4, 6, 10 and 14 days. Plates 10, 11, and 12 shows 4 and 14 days old colonies held at 13–15°C., 28–30°C., and 33–35°C.

From Table 6, it will be noted that growth was obtained between 13°C. and 35°C. but none was obtained at 6–8°C. and at 43–45°C. At 13–15°C. the rate of growth was very slow but continued for some time before the plates were completely ramified by fluffy aërial mycelia. After 14 days none of the strains covered the 9-centimeter plates. The colonies produced by Strains I to VII are thin with fluffy to cobwebby aërial mycelia, and Strain VIII showed also thin colony but are less aërial. Sclerotial formation by Strains I to VI was delayed 25 to 30

days, and were produced scantily, and that even in some plates no sclerotia were formed. Sclerotial formation of Strain VII was also delayed 15 to 20 days, while Strain VIII failed to form its sclerotia even after 35 days at this temperature.

At 18–20°C. all the strains made much faster growth than those observed at 13–15°C. After 4 days, the average growth was from 4.6 to 5.9 cm. and after 6 days all except Strain VII covered the 9-centimeter plate. The type of colony produced

TABLE 6.—*Comparison on the rate of growth of various S. rolfsii "strain" at different temperatures*

Temperature range and days observed	Rate of growth of various *S. rolfsii* "strains"							
	I	II	III	IV	V	VI	VII	VIII
At 6–8° C.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
2 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
4 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
6 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
10 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
14 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
At 13–15° C.								
2 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
4 days	0.9	1.5	1.3	1.2	1.0	1.0	0.8	0.3
6 days	3.0	3.7	4.2	3.7	3.1	2.5	2.0	1.8
10 days	5.5	5.5	5.4	6.1	6.0	5.1	4.0	2.7
14 days	8.3	7.8	8.3	8.8	8.8	8.3	7.5	6.8
At 18–20° C.								
2 days	2.4	2.5	2.4	2.4	2.4	2.2	2.1	2.2
4 days	5.6	5.9	5.8	5.8	5.6	5.8	4.6	5.7
6 days	***	***	***	***	***	***	8.0	***
10 days	***	***	***	***	***	***	***	***
At 28–30° C.								
2 days	4.2	4.0	4.7	4.5	4.7	3.2	2.8	2.6
4 days	***	***	***	***	***	***	8.5	***
6 days	***	***	***	***	***	***	***	***
At 33–35° C.								
2 days	2.5	2.9	3.3	3.1	3.1	2.2	1.6	1.0
4 days	5.6	5.9	8.9	7.3	7.1	3.6	3.4	3.7
6 days	***	***	***	***	***	5.5	5.2	6.7
10 days	***	***	***	***	***	8.4	6.8	***
14 days	***	***	***	***	***	8.5	7.0	***
At 43–45° C.								
2 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
4 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
6 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
10 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
14 days	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace

*** Denotes that colony has already covered the 9-centimeter diameter of the petri-dish

by all the strains are aërial, fluffy to cottony mycelia, but Strains VII and VIII showed thicker and more creeping mycelia. Sclerotia formation by Strains I to VI were noted after 8 to 15 days and more numerous than those produced at 13–15°C. With Strain VII sclerotia formation was noted after 12 to 18 days while Strain VIII only showed "sclerotia initials" which never matured even after 30 days.

At 28–30°C. all the strains made very rapid, excellent, thick growth, and much better than at any other temperature. After 4 days, all the strains, except Strain VII covered the 9-centimeter plate. Slight differences in type of growth were noted. Strains I to VI produced thick, fluffy, cottony to dentritic or feathery colonies, while colonies of Strains VII and VIII were also thick, but their mycelia appeared thicker and coarser than Strains I to VI. At 14 days old, however, marked differences were noted. Strains I to VI have well matted colonies with their numerous sclerotia formed on the colony. Strain VII also has a matted colony like Strains I to VI, but on the colony are found thickened masses of mycelia in "tufts" from which sclerotia were being formed either singly or in groups. Strain VIII, on the other hand produced fine aërial mycelia which ramified all over the plate. Sclerotia formation by Strains I to VI was noted after 4 to 6 days; Strain VII after 8 to 12 days, while Strain VIII failed to produce its sclerotia. (Plate 11 and 12.)

At 33–35°C. all the strains showed slower and somewhat retarded growth than those observed from 28–30°C. After 4 days, the average growth was from 3.4 to 8.9 cm. and after 6 days Strains I to V covered the 9-cubic centimeter plate, while Strains VI, VII, and VIII failed to cover it, showing these strains grew more slowly at this temperature. The type of colony produced at this temperature varied somewhat on different strains. After 4 days Strains I to VI produced thin to thick aërial, flufiy to cottony colony; while Strains VII and VIII which grew very slowly gave a thick colony, with Strain VIII differing from Strain VII in producing thick straight mycelia and the presence of growth ring on the colony. After 14 days, Strains I to VI showed nearly identical matted colonies with abundant mycelia, while Strain VII gave irregular colony, with short, cottony to wooly whitish mycelia and failed to produce sclerotia. Strain VIII differed from the rest of the strains by producing a thin creeping colony with straight coarse mycelia. Sclerotia formation by

Strains I to VI was noted after 4 to 8 days while Strains VII and VIII failed to produce their sclerotia at this temperature.

At 6–8°C. and at 43–45°C. all the strains failed to grow. After 14 days, the plates were taken back at 28–30°C. and after 2 days at this temperature, those previously held at 43–45°C. failed to grow, while those previously held at 6–8°C. gave an average growth ranging from 4.2 to 5.8 centimeters and in a few more days produced their sclerotia, depending upon the strain. In further trials, it was found that the strains could be held at 6–8°C. for as long as 60 days, the longest period tried, without losing their viability, indicating that they were only checked in their vegetative growth at this temperature. Those held at 43–45°C. were greatly affected; after 3 days the colonies were so weakened, and after 4 to 5 days all the strains were dead. Trials were also made at 8–10°C. and found that growth continued very slowly and colony produced by Strains I to VII are aërial, fluffy to cottony, while Strain VIII produced thready-like mycelia on the colony. No sclerotia were produced by any strain even after 60 days.

From these studies it will be noted that the various strains have almost the same temperature requirements, but less active growth, few, if at all, sclerotic formation at lower temperatures, and faster, and more abundant and uniform growth, and earlier formation of sclerotia at higher temperatures. At 13–15°C. the rate of growth was slow and poor, better and faster at 18–20° C., best at 28–30°C. and somewhat retarded at 33–35°C. Figure 2 shows the average growth of various strains after 4 days at various temperatures. At 6–8°C. the fungus remained dormant as long as 60 days without any effect on their viability, while at 43–45°C. their viability was greatly affected, and after 4 to 5 days all the strains were dead. At 8–10°C. growth was obtained but all the strains were in mycelial stages. This result agrees with that of Harter(7) in his studies on the relation of temperatures to production of rots of aroids caused by a strain of *S. rolfsii*. Sclerotia formation by Strains I to VII is likewise influenced by temperature. At lower temperatures their formation was delayed or totally failed to appear but at higher temperatures with the exception of Strain VII at 35°C. Sclerotia were produced earlier and more abundantly by Strains I to VI. Strain VIII at any of these temperatures failed to produce its sclerotia. Basing on these results the optimum temperature for growth for all the strains is placed between 28–30°C., the maximum below 42°C., and the minimum slightly above 8°C.

Effect of temperatures on the germination of sclerotia.—The readiness of the sclerotia of the various strains to germinate is likewise influenced by temperature. In series of experiments, five sclerotia from 20 days old colony of each strain were sown per tube of two in a set containing 5 cc. of nutrient solution.

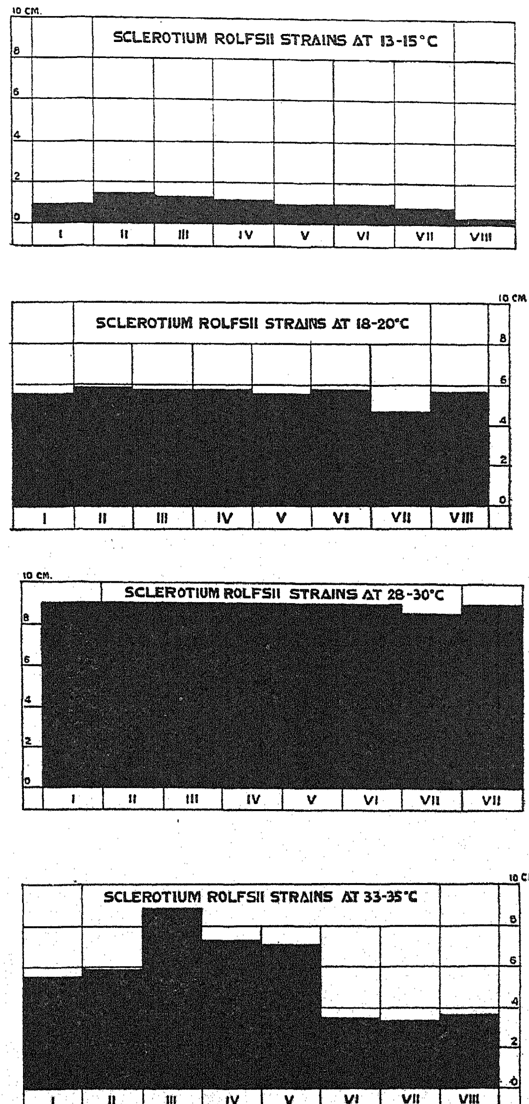

FIG. 2. **Rate of growth of various strains at different temperatures after 4 days on potato agar.**

TABLE 7.—*Germination of 20 days and 90 days old sclerotia of various strains in nutrient solution of different temperatures.*

Temperature at which sclerotia are subjected	Number of hours observed	Per cent germination of 20 days old sclerotia (Series 1)							
		I	II	III	IV	V	VI	VII	VIII
6– 8°C	120	No germination after 120 hours							
13–15°C	12	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0
	48	0	0	0	0	0	0	0	0
	72	0	10	0	0	0	0	0	0
	96	40	10	0	0	20	20	10	0
	120	70	80	70	70	80	90	100	100
18–20°C	12	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0
	48	90	90	80	50	70	70	100	100
	72	100	100	100	100	100	100	100	100
28–30°C	12	0	0	0	0	0	0	20	0
	24	60	90	100	100	100	100	100	100
	48	100	100	100	100	100	100	100	100
33–35°C	12	0	0	0	0	0	0	0	0
	24	0	50	60	40	50	40	100	100
	48	100	100	100	100	100	100	100	100
43–45°C	120	No germination after 120 hours							

Temperature at which sclerotia are subjected	Number of hours observed	Per cent germination of 90 days old sclerotia (Series 2)							
		I	II	III	IV	V	VI	VII	VIII
6– 8°C	120	No germination after 120 hours							
13–15°C	12	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0
	48	0	0	0	0	0	0	0	0
	72	0	0	0	10	0	10	0	0
	96	0	0	0	10	0	10	0	0
	120	50	0	0	20	0	10	20	100
18–20°C	12	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	100	0
	48	50	10	60	10	60	80	100	100
	72	100	100	100	80	100	100	100	100
28–30°C	12	0	0	0	0	0	0	0	0
	24	70	30	70	70	80	60	100	100
	48	100	100	100	100	100	100	100	100
33–35°C	12	0	0	0	0	0	0	0	0
	24	80	40	70	80	100	90	80	100
	48	100	100	100	100	100	100	100	100
43–45°C	120	No germination after 120 hours							

With Strain VIII, which does not produce sclerotia freely, 3 mm. mycelial blocks from 3 days old colony were used. The tubes were then incubated at the same range of temperatures already mentioned above, and notes were made after 12, 24, 48, 72, 96, and 120 hours.

As shown on Table 7, series 1, the sclerotia failed to germinate even after 120 hours at 6–8°C. and at 43–45°C. At 13–15°C. the rate of germination was very slow; even after 72 hours 0 to 10 per cent germination was noted depending upon the strains. After 120 hours not all the strains gave 100 per cent germination. At 18–20°C. germination was much faster than those observed at 13–15°C. After 48 hours, from 50 to 100 per cent of the sclerotia germinated and after 72 hours all the strains gave 100 per cent germination. At 28–30°C. and 33–35°C., the germination of sclerotia was the best and earliest of all, as after 48 hours all the strains gave 100 per cent germination.

The above results were confirmed in a set of experiments where 90 days old sclerotia of each strain were tested, using the same stock of nutrient solution as above. Again, no germination was obtained at the lowest and highest temperatures, poor and slow at 13–15°C. and better at 18–20°C. and best at 28–30°C. and 33–35°C. (Table 7, Series 2). In these two series, differences were noted in the readiness of 20 days old and 90 days old sclerotia to germinate. The 90 days old sclerotia showed delayed germination at lower temperatures but at the favorable warm temperatures no difference was noted between the 20 and 90 days old sclerotia. Based on these results, no marked difference could be found between the strains in regards to temperature requirements for germination of their sclerotia and the optimum, maximum, and minimum temperature for sclerotia germination is identical as those temperatures already observed for vegetative growth and sclerotia formation mentioned above.

Germination of sclerotia in organic and inorganic solutions.— The sclerotia of the various strain germinated readily at certain concentrations of organic and inorganic solutions. In a set of experiments five sclerotia from 20 days old colony of each strain were placed to each tube in a set of four tubes, each containing 5 cc. of 1, 2, and 5 per cent glucose, sodium chloride, citric acid, and tartaric acid, and nutrient solution, tap and sterile water. As a check on the germinability, 10 sclerotia from the same

colonies of each strain were plated on the same day on poured potato agar. All were incubated at 28–32° C. and notes were made after 2, 4, 8, and 12 days.

As shown on Table 8 good an early germination was noted at the lower concentration of sodium chloride, citric acid, tartaric acid, glucose solution and on nutrient solution, tap water, and sterile water, while at higher concentrations of citric and tartaric acid, and on sodium chloride, germination was very slow and delayed. The differences noted in the percentage of germination at these various concentrations are considered not significant in distinguishing one strain from another. Fast germination was noted on 1, 2, and 5 per cent glucose, nutrient solution, and in 1 to 2 per cent citric and tartaric acid, while on tap water, sterile water or 2 per cent, 5 per cent sodium chloride, and 5 per cent citric and tartaric acid, germination was slow or delayed. In this connection the amount of mycelial growth varied in the different germinating media. The various solutions of glucose supported fairly good growth and poor to fairly good from various solutions of sodium chloride, 5 per cent citric and tartaric acid, and tap and sterile water. The best growth was obtained from nutrient solution and 1 and 2 per cent citric and tartaric acid.

STUDIES ON THE BIOLOGY OF *S. ROLFSII*

Viability of sclerotia on surface of dry and moist soil.—The sclerotia of *S. rolfsii* more readily germinate on the surface of moist soil than on the surface of dry soil. In a series of experiments, samples of sclerotia of Strains I and II were sown on surface of moist sandy and heavy soil placed in wire baskets. In order to keep the surface soil moist, the baskets were stood in a pan of water so that one inch of the bottom is immersed. Simultaneously with these experiments, samples of sclerotia were also sown on the surface of dry sandy and heavy soil. All were left at room temperature (28–32°C.) and the sclerotia which germinated were removed and counted from time to time until no further germination was observed.

From Table 9 it will be seen from the first series that most of the sclerotia germinated between the second to the fourth day, on the second series, germination continued to the eighth day; and on the third series, germination continued until the end of

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[a] Unless otherwise stated only Strains I or II which are the most common strains of *S. rolfsii* isolated on tomato are used in the following studies.

TABLE 8.—*Germination of sclerotia of S. rolfsii on various organic and inorganic solutions*

Strains	Germinating solutions [a]														
	Glucose			Sodium chloride			Citric acid			Tartaric acid			Nutrient solution	Tap water	Sterile water
	1%	2%	5%	1%	2%	5%	1%	2%	5%	1%	2%	5%			
(4 days)															
I	40	60	40	60	0	0	100	100	40	100	100	0	100	20	40
II	100	100	100	100	100	100	100	100	0	100	40	0	100	80	100
III	100	80	100	100	100	0	100	80	0	100	100	0	100	80	60
IV	80	100	100	60	0	0	100	100	0	100	100	0	100	60	40
V	100	80	100	60	40	0	100	80	0	100	100	0	100	100	100
VI	100	100	100	100	40	0	100	100	0	100	100	0	100	100	60
VII	100	100	100	100	100	80	100	100	100	100	100	66	100	80	80
VIII	100	100	100	100	100	0	100	80	100	100	80	100	100	100	100
(8 days)															
I	100 (++)	100 (++)	100 (++)	80 (+)	0	0	100 (++++)	100 (++)	80 (++)	100 (++++)	100 (+++)	100 (++)	100 (++++)	60 (+)	100 (+)
II	100 (+)	100 (++)	100 (+)	100 (+)	100 (+)	100 (+−)	100 (++++)	100 (+++)	100 (++)	100 (++++)	100 (+++)	100 (++)	100 (++++)	80 (+)	100 (+)
III	100 (++)	100 (++)	100 (+)	100 (+)	100 (+)	60 (+)	100 (++++)	80 (+++)	100 (+)	100 (++++)	100 (++++)	66 (+)	100 (++++)	80 (+)	100 (+)
IV	100 (++)	100 (++)	100 (+)	60 (+−)	20 (+−)	0	100 (++++)	100 (+++)	100 (+)	100 (++++)	100 (+++)	100 (++)	100 (++++)	60 (+)	100 (+)
V	100 (++)	100 (++)	100 (+)	60 (+)	80 (+)	60 (+)	100 (++++)	80 (++)	100 (+−)	100 (++++)	100 (+++)	100 (++)	100 (++++)	100 (+)	100 (+)
VI	100 (++)	100 (++)	100 (+)	100 (+)	100 (+)	40 (+)	100 (++++)	100 (+++)	80 (+−)	100 (++++)	100 (+++)	100 (+)	100 (++++)	100 (+)	100 (+)
VII	100 (++)	100 (++)	100 (++)	100 (++)	100 (++)	80 (++)	100 (++++)	100 (+++)	100 (++)	100 (++++)	100 (++++)	100 (+)	100 (++++)	80 (+)	100 (+)
VIII	100 (+)	100 (+)	100 (+)	100 (+)	100 (+)	100 (+−)	100 (++++)	80 (++++)	100 (++)	100 (++++)	100 (+++)	100 (+++)	100 (++++)	100 (+)	100 (+)

[a] The symbol represents density of mycalial growth; +— very poor mycelial growth, + poor to fair mycelial growth, ++ good mycelial growth, +++ very good mycelial growth, ++++ excellent mycelial growth

TABLE 9.—*Germination of sclerotia on surface of moist sandy and heavy soil*

Strains used	Kind of soil used	Number of sclerotia started	Number of sclerotia germinated after, number of days											Total number of sclerotia germinated	Per cent germination	Total not germinated
			1	2	4	6	8	10	12	14	16	18	20			
Series 1																
Strain I	Sandy	50	------	14	12	------	------	------	------	------	------	------	------	26	52.0	[a] 24
	Heavy	150	------	35	110	------	------	------	------	------	------	------	------	145	96.6	[a] 5
Series 2																
Strain II	Sandy	250	46	164	17	5	1	------	------	------	------	------	------	233	93.2	[a] 17
	Heavy	200	22	86	45	33	2	------	------	------	------	------	------	188	94.0	[a] 12
Series 3																
Strain I	Sandy	200	2	3	15	36	39	------	16	24	22	23	------	180	90.0	[a] 20
	Heavy	350	5	14	140	85	17	2	23	19	15	5	------	325	92.8	[a] 25

[a] These sclerotia when surface sterilized, then plated on potato agar and incubated at 28–32° C. gave from 50 to 100 per cent germination, showing them still viable.

18 days, showing that in a sample of sclerotia which are in contact continuously on the surface of moist soil, that germination of sclerotia may be expected even until the 18th day or longer. In these series, the other sclerotia which failed to germinate on the surface of moist soil were found still viable and gave high percentage of germination when they were surface sterilized and were plated on potato agar. The sample of sclerotia left to germinate on the surface of air dry soil failed to germinate *in sitio*, even after 30 days. However, when sample of them were surface sterilized and were plated on potato agar, high percentage of germination was also obtained. The length of time that sclerotia may be kept on moist or dry soil and still remain viable was not determined, but it is believed they can resist longer periods, as field observations have shown that after few months of dry or rainy weather in the Philippines, sclerotia may be found to germinate readily as soon as favorable conditions are again present or when given suitable medium in the laboratory.

Viability of sclerotia in the soil.—The viability of sclerotia is greatly affected at certain depths they are buried in the soil. In a series of experiments, samples of sclerotia from Strain I were buried from 1 to 2 inches deep in moist soil put in wire basket which was stood in a pan of water so that one inch of the bottom is continuously immersed. Simultaneously with this series, samples of sclerotia were also buried 2 inches deep in a soil put in another basket which was completely immersed in water, so that the sclerotia were continuously flooded. After a certain number of days, samples of sclerotia were recovered, washed, surface sterilized, and then plated on poured potato agar. As shown on Table 10, Series 1, those buried 1 and 2 inches deep in moist soil for 40 days, gave 60 and 50 per cent viable sclerotia, respectively, while those buried 2 inches deep but flooded for 40 days gave 75 per cent viable sclerotia.

In another series, samples of sclerotia were buried at 1, 2, 3, 4, 5, and 6 inches deep in fairly moist soil placed in celluloid cylinders. After 5, 15, 30, 45, and 60 days, samples of sclerotia were recovered, surface sterilized, and plated on potato agar as before. The result which is summarized in Table 10, Series 2, shows that the sclerotia may be buried 4 inches deep in fairly moist soil for 60 days with only slightly affecting their viability giving still 60 per cent germinable sclerotia. Those buried 5 and 6 inches deep greatly affected their viability, as after 45 and

60 days those buried at 5 inches deep gave 10 per cent and 15 per cent viable sclerotia, respectively, while those buried at 6 inches deep for 45 and 60 days gave 0 per cent viable sclerotia.

From these results it will be seen that the scletoria may be buried 4 inches deep in moist soil for 60 days or buried 2 inches deep in flooded soil for 40 days, the longest period tried, without affecting their viability greatly, while those buried 5 and 6 inches deep showed a great reduction of viability after 45 or 60

TABLE 10.—*Viability of sclerotia in the soil*

Condition of soil	Dept of scloretia	Number of days	Number of sclerotia plated	Number of sclerotia germinated	Per cent germination
Series 1					
Moist	1 inch	5	25	22	88
Moist	1 inch	20	37	19	51
Moist	1 inch	40	20	12	60
Moist	2 inches	5	75	72	96
Moist	2 inches	20	35	14	40
Moist	2 inches	40	20	10	50
Flooded	2 inches	6	46	44	96.5
Flooded	2 inches	14	20	16	80.0
Flooded	2 inches	24	20	9	45.0
Flooded	2 inches	40	24	18	75.0
Series 2					
Moist	1 inch	30	10	10	100
Moist	1 inch	45	10	9	90
Moist	1 inch	60	10	10	100
Moist	2 inches	30	10	10	100
Moist	2 inches	45	10	9	90
Moist	2 inches	60	10	10	100
Moist	3 inches	30	10	10	100
Moist	3 inches	45	10	4	40
Moist	3 inches	60	10	7	70
Moist	4 inches	30	10	10	100
Moist	4 inches	45	10	5	50
Moist	4 inches	60	10	6	60
Moist	5 inches	30	10	10	100
Moist	5 inches	45	10	1	10
Moist	5 inches	60	20	3	15
Moist	6 inches	30	10	10	100
Moist	6 inches	45	10	0	0
Moist	6 inches	60	10	0	0

days. The time limit in which the sclerotia may be buried in flooded or moist soil and still retain its viability was not determined. Tisdale(17), however, found that the sclerotia of *S. rolfsii* from rice gave 100% viable sclerotia even after continuously immersing them in water in the laboratory or in the field for over 3 months. Unless other factors play in reducing the viability of the sclerotia in the soil, our rainy season in the Philippines perhaps is not long enough to completely kill all the sclerotia in the soil as the fungus reappear in the same piece of land or in the same locality from one year to another.

Depth in which the fungus is buried in relation to infection.—Taubenhaus(15) found that for successful inoculation it is necessary to cover the fungus not more than ½ to 1 inch deep, and no infection is possible if either the mycelium or sclerotia are buried more than 5 inches deep. Atienza(1) in his stuides on sclerotium disease on tomato and pepper found that sclerotia buried deeper than 1.5 cm. deep only showed 15 per cent infection.

In our studies young tomatoes were planted in a soil put in cylinder where the sclerotia and mycelia of 5 days old colony were placed on the surface and at 1, 2, 3, 4, 5, and 6 inches deep. Rapid infection and death of plants were observed after 2 to 5 days where the sclerotia and mycelia were on the surface or buried 1 inch deep. Delayed infection was noted where the fungus was buried 2 inches deep and the infection of 2 plants out of 5 under observation resulted only where the fungus followed up the loose soil near the edge of the cylinder and came to the surface. No infection resulted where the sclerotia or mycelia were buried 3, 4, 5, and 6 inches deep even after 25 days when the observations terminated. The results, therefore, show that the fungus is very active and readily caused infection when it is near the surface but may become inactive and incapable of infecting susceptible plants when buried 2 to 6 inches deep unless brought toward the surface by cultivation or other means. Plate 3 shows the result of these infection experiments four days after inoculation.

Longevity of sclerotia and mycelia in the laboratory.—Tisdale(17) finds that the sclerotia of *S. rolfsii* from rice kept in a dry condition for 9 months germinated readily when placed under proper conditions of moisture and temperature. Thompson(16) also states that one year old culture placed in water until swollen failed to germinate when placed on tubers, but when they were removed and placed on maize agar, growth occurred

and on inoculation caused the tubers to rot. Higgins (8) also finds that the sclerotia of *S. rolfsii* kept in dry test tubes germinate readily on fresh media when two years old.

In our test on longevity of sclerotia in the laboratory, 7 months old sclerotia gave 100 per cent germination, while those of 8, 12, and 16 months old gave 75, 20, and 0 per cent germination, respectively. In another set, sample of sclerotia varying in age from 7, 9, 12, 14, 16, and 18 months old colonies of *S. rolfsii* from tomato, rice, and pepper were plated on potato agar and incubated at 28–32°C. Those from 7 to 9 months old sclerotia gave high per cent germination while those from 12 months old gave from 5 to 20 per cent germination depending upon the strain. After 14 months, however, the germination of sclerotia from tomato was reduced to 1.7 per cent, and the pepper and rice strain both gave 0 per cent. After 16 months all the sclerotia from these strains were dead, showing that the common strain of *S. rolfsii* in the Philippines may be greatly reduced in viability after 12 to 14 months in the laboratory, and after 16 motnhs they are dead. (Table 11.)

TABLE 11.—*Viability of sclerotia under dry condition in the laboratory*

Age of sclerotia	Tomato		Pepper		Rice	
	Number of sclerotia plated	Per cent germination	Number of sclerotia plated	Per cent germination	Number of sclerotia plated	Per cent germination
Month						
7	40	100.0	20	100	20	100
9	40	22.5	20	25	20	50
12	40	5.0	20	20	20	5
14	57	1.7	20	0	20	0
16	40	0	20	0	20	0
18	40	0	20	0	20	0

Tests were also made on the viability of mycelia in the laboratory. In a series of experiments bits of aërial mycelia adhering on the side of culture tubes from 5 and 7 months old colonies when plated on potato agar were found still viable, but those from 8 or 10 months old were dead. Mycelia in blocks cut from 3 days old colony when allowed to dry separately in petri dishes in the laboratory were found to die sooner than those cultures kept in test tubes. The results, therefore, show that the mycelia of the fungus lose their viability sooner in the laboratory than the sclerotia.

Thermal tolerance of sclerotia and mycelia.—The sclerotia is more tolerant at higher temperatures than the mycelia of the fungus. In this experiment, mycelia in 3 mm. blocks from 3 days old colony and samples of sclerotia from 20 days old colony were heated at various length of time in test tubes containing 10 cc. of warm water heated at 48–50°C., 50–52°C., and 60–62°C. In order to keep the temperature of the water in the test tubes uniform, they were heated in a water bath which was constantly stirred. Previously, either the mycelia or sclerotia were dropped, reading of the temperature was made before and during the treatment. After the treatment, the test tubes were immersed in cold water, or sterile cold water was added. The mycelia or sclerotia were plated on potato agar and incubated at 28–32°C. for 3 days. As shown on Table 12 the mycelia were killed after 3 minutes exposure at 48–50°C., while the sclerotia withstood it even as long as 7 minutes giving 6 per cent germination. At 50–52°C., the mycelia were killed after 3 minutes, while the sclerotia withstood 5 minutes and gave 30 per cent germination, but, after 10 minutes, all were also killed. At 58–60°C. and at

TABLE 12.—*The viability of mycelia and sclerotia of S. rolfsii at various temperatures*

Temperature range	Duration of exposure	Number of mycelial blocks plated	Per cent germination	Number of sclerotia plated	Per cent germination
	Min.				
48–50°C	1	10	100	20	100
	2	10	100	20	100
	3	10	0	20	50.0
	4	10	0	18	83.3
	5			20	50
	6			20	50
	7			30	6.66
	8			20	0
50–52°C	1	5	100	20	100
	2	5	20	20	100
	3	5	0	20	100
	5			20	30
	10			20	0
58–60°C	1	10	0	19	84.21
	2	10	0	19	84.21
	3			20	80
	4			20	30
	5			20	0
	6			20	0
60–62°C	1	10	0	10	30
	2			20	0
	3			20	0

60–62°C., the mycelia were all killed after 1 minute exposure, while the sclerotia at 58°–60°C. were killed after 5 minutes exposure, and at 60–62°C. they were also killed after 2 minutes exposure, showing that the sclerotia are more tolerant to heat than the mycelia.

RELATIVE SUSCEPTIBILITY OF TOMATO VARIETIES

As discussed above, the various "strains" are all equally aggressively pathogenic on tomato and other economic plants. Test was made to determine the relative susceptibility of certain commercial American and native tomato varieties. For this purpose, Strain I, which is a common strain isolated from tomato and from peanut was used. Twenty-five to 30 days old seedlings growing in 8-inch pots were inoculated in the greenhouse, by placing the inoculum near the stem of one plant in the center of the pot. The plants were then enclosed in celluloid cylinders, the top of which was left uncovered and kept moist by sprinkling water from time to time. As shown in Table 13 the va-

TABLE 13.—*Relative susceptibility of commercial tomato varieties to S. rolfsii (Strain I)*

Variety name	Number of plants inoculated	Number of plants infected	Per cent infected
Acme	40	4	10.0
Beef Steak	31	11	35.5
Bonny Best	44	14	31.8
Break O'Day	32	23	[a] 71.8
Burpee's Fordhook First	31	8	25.8
Burpee's Matchless	32	29	[a] 90.6
Burpee's Self-pruning	22	8	36.3
Burpee's Tangerine	26	20	[a] 76.9
Chalk's Early Jewel	52	20	38.5
Dwarf Stone	46	4	8.7
Early Detroit	39	15	38.2
Giant Ponderosa	15	2	13.3
Golden Queen	33	21	63.6
Greater Baltimore	62	4	6.5
Gulf State Market	38	30	[a] 78.9
Gulf State Market	35	32	[a] 91.4
June Pink	25	9	36.0
Penn State Earliana	31	21	67.7
Stone	46	40	[a] 87.0
Strawberry or Husk	36	18	50.0
The Burpee	21	1	4.8
Trucker's Favorite	39	27	69.2
True Giant Ponderosa	39	9	23.1
Whole Salad	13	11	[a] 84.5
Native (Pasig)	25	15	60.0
Native (Calumpit)	25	20	80.0

[a] All the plants from these varieties later died.

rieties are all susceptible, but variation in susceptibility was noted depending upon the different varieties. The Burpee, Greater Baltimore, Dwarf Stone, and Acme were less affected. The fungus on these varieties spread slowly affecting only few plants after the end of the experiment. The other varieties which are more susceptible showed many dead plants within a few days, and on these dead plants abundant sclerotia were produced.

DISCUSSION

The fungus *S. rolfsii* is also a common soil parasite attacking tomato, peanut and other economic ornamental and weed plants in the Philippine Islands. In other countries, biologic strains or forms have been found or recognized by certain writers(3) (16). In the Philippines, the eight isolations of *S. rolfsii* on different hosts from different regions of Luzon Island which were studied culturally have shown three distinct "strains" or forms which might be distinguished from each other by differences in the rate of growth, type of colony, time of sclerotia formation, and in the number, size or color of sclerotia produced.

Strains I to VI, which were isolated on either tomato, peanut, bean or pineapple showed slight differences in their morphology and are considered identical or the same strain. Strain VII might be distinguished from Strains I to VI in being slow grower, produces thicker, coarser, or fluffier mycelia, and few, big sclerotia which are formed much later than Strains I to VI at ordinary temperatures. At 33–35°C. this strain failed to produce its sclerotia, while Strains I to VI at this temperature produced abundant sclerotia. Strain VIII is also a slow grower, but differed from Strain VII Ior from the rest of the strains, not only in the type of colony, but also in not producing its sclerotia freely in culture at any temperature to which it was subjected. The distribution of these last two strains is not so wide as those of Strains I to VI. Strains I to VI are generally found in most of the agricultural provinces of Luzon, and in the important truck farming region of Trinidad Valley, Mountain Province. Strain VII was isolated from Batac, Ilocos Norte, in Northern Luzon, and Strain VIII was isolated at the foot of Mount Banahaw, Lilio, Laguna, in Southern Luzon. Even if extensive cross inoculation tests are lacking to determine physiological differences, if any, the morphological differences of these three "strains" or forms are so distinct, and suffice that they are all aggressively parasitic on our economic plants of the Philippines.

These strains have almost identical temperature requirements, and why this is so can not be explained at this time. The results, however, indicate that any of these strains will survive our minimum or maximum temperatures, and even in Baguio, or Trinidad Valley, Mountain Province, where the temperature may reach as low as 6° to 10°C. for a few days during the year. Therefore, unless other factors check their viability or increase in the soil, they will remain either as mycelia or sclerotia in the soil, and continuously become a serious agricultural problem every year.

No experiments were undertaken on the control of the disease, but, certain precautionary measures based on the biology of the fungus will greatly reduce the disease in the field. The fungus is very actively parasitic when it is near the surface of the soil, and when there is abundant moisture. Plowing infested field 4 to 8 inches deep or more, regulating the amount of moisture sufficient to support normal growth of plants, or timing the season of planting will greatly reduce the loss which might be due to the disease. The fungus is carried from one place to another either with infected seeds, tubers, seedlings or with the soil. Care should, therefore, be taken to avoid its introduction to new fields by using only disease-free seeds, tubers, and uninfected seedlings, and if necessary, these propagative parts may be disinfected or immersed in hot water, the temperature and duration of exposure should vary in each particular case. Infected plants in the field should be dug up including the soil surrounding it and removed and burned. For small garden plots, or potted soil which are infected, sterilization by "firing," by chemicals, or by changing the infected soil with fresh uninfected soil is very desirable. The selection of resistant plants to control the disease is feasible, but it takes time. In view of the possible presence of biologic strains, development for resistance should be done locally. So far, no chemical is known to completely control the disease.

SUMMARY

1. The fungus *S. rolfsii* is a common soil parasite attacking tomato, peanut, and other economic as well as ornamental plants in the Philippines. The loss owing to it varies with the locality and the kind of crop affected.

2. The symptom of tomato plant affected by *S. rolfsii* is briefly described.

3. Eight different isolations of *S. rolfsii* from different regions of Luzon Island are all aggressively parasitic on most of our economic plants. No attempt was made to find the host ranges of each of these strains.

4. In culture, these eight different isolations may be divided into three distinct strains as shown by differences in their rate of growth, type of colony, time of sclerotia formation, and in the number, size and color of sclerotia.

5. Strains I to VI, which are isolated from either tomato, peanut, bean or pineapple showed only slightly differences and are considered identical or the same. These strains appear to be the most common strain found from most agricultural regions of Luzon.

6. Strain VII differed from the above strains in being slow grower, with thicker or coarser mycelia and produced few, big, ovoid to very irregular shape sclerotia. At 33–35°C., this strain failed to produce sclerotia while Strains I to VI produced their sclerotia abundantly.

7. Strain VIII is also a slow grower like Strain VII, but it differs from Strain VII or from Strains I to VI not only on the type of colony produced, but also in its failure to produce sclerotia on any culture media or at any temperature to which it is subjected. The color of sclerotia or size of sclerotia when produced also differed from the rest of the strains. This strain appeard to be limited in its distribution.

8. No marked difference was noted in regards to their temperature requirements for growth, for sclerotia formation or for germination of sclerotia. Growth was obtained between 10°C. to 35°C. with optimum between 28–30°C, maximum slightly below 42° and the minimum at about 10°C. At 6–8°C., all the strains were checked in growth and remained dormant and at 42–45°C. were also checked in growth but were killed after 3 to 5 days exposure.

9. The sclerotia of various strains germinated readily on nutrient solution, on lower concentration of citric and tartaric acids, and on 1 to 5 per cent glucose. Fairly good germination were also obtained with 1 to 2 per cent sodium chloride and on tap and sterile water.

10. The viability of the sclerotia of the common strain of *S. rolfsii* was studied, and found to germinate readily on surface of moist soil, and even if it fails to germinate under this condition

for more than 10 days they were still found viable when plated on potato agar.

11. Burying the sclerotia even as deep as 4 inches in moist soil or buried 2 inches in flooded soil from 40 to 60 days did not materially affect their viability as these sclerotia, when recovered and plated, showed high percentage of viable sclerotia. Those buried 5 to 6 inches deep were greatly affected, and after 45 to 60 days nearly all the sclerotia were dead.

12. The sclerotia or mycelia are only very active when they are near the surface of moist soil. Infection was obtained on susceptible plants when the mycelia or sclerotia of the fungus are on the surface or buried 1 inch deep. Delayed infection was noted with the fungus buried 2 inches deep, and no infection was obtained where the fungus was buried at 3, 4, 5, and 6 inches deep.

13. The sclerotia could resist longer drying period in the laboratory than the mycelia. Under our tests, the mycelia were dead after 8 months, while the sclerotia were not all dead after 12 months.

14. The sclerotia are more tolerant to heat than the mycelia. The mycelia were killed at 48–50°C. and at 50 to 52°C. after 3 minutes exposure, and at 58–60°C. and at 60–62°C. after 1 minute exposure. The sclerotia withstood all the first three temperature ranges with longer exposure, but at 60°–62°C. the sclerotia were also killed after 1 minute exposure.

15. Certain commercial varieties of tomatoes were tested and found all susceptible to the common strain of *S. rolfsii.* The relative susceptibility, however, varied with the strains.

16. Suggestions for control of the disease is briefly discussed.

LITERATURE

1. ATIENZA, MAXIMINO. Sclerotium Disease of Tomato and Pepper. *Phil. Agr.* 15 (1927). 579–587.
2. EDGERTON, C. W. and C. C. MORELAND. Diseases of the tomato in Louisiana. *La. Agr. Exp. Sta. Bul.* 142 (1913): 23p.
3. EDSON, H. A. and M. SHAPOVALOV. Parasitism of *S. rolfsii* on Irish potatoes. *Jour. Agr. Res.* 23 (1923); 41–46.
4. FAJARDO, T. G. Sclerotium Stem Rot of Delphinium and Other Ornamental Plants in Trinidad Valley, Mountain Province, Philippine Islands. *Phil. Jour. Sci.* 51 (1933): 447–456.
5. FULTON, H. R. Diseases of Pepper and Beans. *La. Agr. Exp. Sta. Bul.* 101 (1908) 21 p.
6. GODFREY, G. H. Sclerotium Rolfsii on Wheat. *Phyt.* 8 (1918): 64–66.
7. HARTER, L. L. Storage Rots of Economic Aroids. *Jour. Agr. Res.* 6 (1916): 459–511.

8. HIGGINS, B. B. Notes on the Morphology and Systematic Relationship of *S. rolfsii Sacc. Jour. of the Elisha Mitchell Scientific Soc.* 37 (1922): 167–172.
9. ———. Physiology and Parasitism of Sclerotium Rolfsii. Sacc. *Phyt.* 17 (1927): 417–488.
10. MCCLINTOCK, J. A. Peanut Wilt Caused by Sclerotium Rolfsii. *Jour. Agr. Res.* 8 (1917): 441–448.
11. OCFEMIA, G. O. Notes on Some Economic Plant Diseases New in the Philippine Islands. *The Phil. Agr.* 10 (1924): 331–345.
12. PELTIER. G. L. A Serious Disease of Cultivated Perennials Caused by Sclerotium Rolfsii, *Ill Agr. Exp. Sta. Cir.* 187 (1916) 3 p.
13. ROLFS, P. H. The Tomato and Some of Its Diseases: Diseases of other plants. *Fla. Agr. Exp. Sta. Bul.* 21 (1893): 25–36.
14. REINKING, O. A. Philippine Economic Plant Diseases. *Phil. Jour. Sci. Sec.* A. 13 (1918): 165–274.
15. TAUBENHAUS, J. J. Recent Studies on *Sclerotium rolfsii Sacc. Jour. Agri. Res.* 18 (1918): 127–138.
16. THOMPSON, A. Notes on Sclerotium Rolfsii Sacc. in Malaya. *Malayan Agr. Jour.* 16 (1928): 48–58.
17. TISDALE, W. H. Two Sclerotium Diseases of Rice, *Jour. Agr. Res.* 21 (1921): 649–658.
18. WEBER, G. F. Blight of Carrots Caused by Sclerotium Rolfsii, with Geographic Distribution and Host Range of the Fungus. *Phyt.* 21 (1931) 1129–1140.

ILLUSTRATIONS

PLATE 1

FIGS. 1. and 2. Mature tomato plants showing injury on the stem caused by *S. rolfsii*. The thick, white mycelia of the fungus may be seen.

3. An enlarged photograph of Fig. 2, showing more distinctly the type of injury. The thick, white mycelia of the causal fungus is seen extending up the stem.
4. Tomato fruit naturally infected in the field in Trinidad Valley, Mountain Province. The basal end of the fruit is rotted and the young sclerotia of the fungus may be seen.
5. Rotted tomato stem showing the development of sclerotia inside the stem. The stem is opened to show the sclerotia in the pith cavity.

PLATE 2

FIG. 1. Infected tomato stem put in moist petri dish for 48 hours at 28–32°C. Thick white strands of mycelia are developed from which a pure culture of *S. rolfsii* may be obtained.

2. A common table beet naturally infected in the field by *S. rolfsii*. The basal end was completely rotted resulting in the death of the plant.

PLATE 3

FIG. 1. Young tomato plants planted in soil put in celluloid cylinders where the fungus was buried 1 inch deep. Four plants died after 4 days and the other died later.

2. Tomato plants planted where the fungus was burried 2 inches deep. No infection resulted after 4 days, but later on, two plants became infected when mycelia of the fungus spread toward the surface.
3. 4, 5, and 6. Young tomato plants planted on the same day as those shown in Figs. 1 and 2, but the fungus was buried 3, 4, 5, and 6 inches deep. No infection resulted and the plants remained healthy until the end of the experiment.
7. Peanut plants artificially inoculated by placing bits of mycelia from a young colony of *S. rolfsii* near the stem. Three of the plants became infected; after 10 days they began wilting.
8. Peanut plants which served as check and was not inoculated.
9. and 10. Two of the peanut plants shown in Fig. 7 showing the injury on the stem.

PLATE 4

Comparison on the type of colony produced by various strains on different culture media (3 days old colony).

FIG. 1. (Left to right), shows strains II, III, IV on potato agar.

FIG. 2. (Left to right) shows Strains VI, VII, VIII on potato agar.
3. (Left to right) shows Strains IV, VII, VIII on malt agar.
4. (Left to right shows Strains II, III, and IV on oatmeal agar.
5. (Left to right) shows Strains VI, VII and VIII on oatmeal agar.

The type of colonies produced by the various strains showed slight differences when the colonies are young.

PLATE 5

Comparison on the type of colony produced by Strains II, VII, and VIII on different culture media (12 days old).

FIG. 1. Strains II, VII, and VIII on potato agar.
2. Strains II, VII, and VIII on malt agar.
3. Strains II, VII, and VIII on oatmeal agar.
4. Strains II, VII, and VIII on peanut agar.
5. Strains II, VII, and VIII on corn meal agar.

Differences on the type of colony produced by Strain II, as is true with Strains I, III, IV, V, and VII differed markedly from Strain VII or Strain VIII. Strain II produced abundant sclerotia, Strain VII, few and limited, while Strain VIII produced fine, fluffy to stringy mycelia ,but failed to produce sclerotia. Only sclerotia "initials" were produced by this strain which never matured even after 30 days on potato agar.

PLATE 6

Comparison on the type of colony produced by various strains on diffrent culture media (22 days old).

FIG. 1. Strains II, III, and IV on potato agar.
2. Strains V, VII, and VIII on potato agar.
3. Strains II, III, and IV on peanut agar.
4. Strains V, VII, and VIII on peanut agar.
5. Strains VI, VII, and VIII on oatmeal agar.

Differences are noted in the type of colony and in the number of sclerotia produced by each strain. Strains VII produced few, but larger sclerotia than Strains I to VI. Strain VIII failed to produce sclerotia, but its sclerotia initials are very evident on potato agar, and oatmeal agar.

PLATE 7

Comparison on the type of colony produced by strains I to VI on steamed cornmeal, cornmeal agar and steamed oatmeal.

FIG. 1. Strains I, II, and III on steamed cornmeal.
2. Strains I, II, and III on cornmeal agar.
3. Strains IV, V, and VI, on steamed cornmeal.
4. Strains I, II, and III on steamed oatmeal.
5. Strains IV, V, and VI on steamed oatmeal.

Strains I, II, IV, and V on steamed cornmeal produced earlier and very abundant sclerotia than Strain III or Strain VI. The sclerotia produced on this media is more numerous than the same

strain on cornmeal agar. On steamed oatmeal less abundant sclerotia was produced by Strains I to V, and Strain VI delayed and very few sclerotia produced in comparison with the other strains.

PLATE 8

Comparison on the type of colony produced by various strains on different culture media (12 days old).

FIG. 1. Strains III, VII, and VIII on steamed corn meal (12 days).
2. Strains III, VII, and VIII on corn meal agar (12 days).
3. Strains VI, VII, and VIII on steamed oatmeal (12 days).
4. Strains VI, VII, and VIII on oatmeal agar (12 days).
5. Strains IV, VII and VIII on steamed oatmeal (4 days).

Marked differences are noted on the 12 days old colonies of Strains VII and VIII from the other strains, Figs. 1, 2, 3, and 5. On Fig. 5 slight differencees are noted on the 4 days old colony of Strains IV, VII, and VIII.

PLATE 9

Comparative sizes of sclerotia of various strains.

FIG. 1. (Left to right) plate culture of Strains VI and VII on steamed oatmeal agar (25 days old).
2. (Left to right) sclerotia produced by Strains VI and VII on potato agar (about 2.4 times).
3. (Left to right) sclerotia of Strains I, II, and IV on potato agar (about 2.4 times).

PLATE 10

Comparison on type of colony produced by various strains at 13–15°C., 28–30°C. and 33–35°C. (4 days old)

FIG. 1. Strain I at 13–15° C., 28–30°C. and 33–35°C.
2. Strain IV at 13–15°C., 28–30°C., and 33–35°C.
3. Strain VI at 13–15°C., 28–30°C., and 33–35°C.
4. Strain VII at 13–15°C., 28–30°C., and 33–35°C.
5. Strain VIII at 13–15°C., 28–30°C., and 33–35°C.

PLATE 11

Comparison on the type of growth produced by Strains I, II, III, and IV at 13–15° C., 28–30°C. and 33–35°C. (14 days old).

FIG. 1. Strain I at 13–15°C., 28–30°C., and 33–35°C.
2. Strain II at 13–15°C., 28–30°C., and 33–35°C.
3. Strain III at 13–15°C., 28–30°C., and 33–35°C.
4. Strain IV at 13–15°C., 28–30°C., and 33–35°C.

Differences are noted in the type of colony produced at different temperatures, but no marked differences could be noted between the strains when incubated at the same temperature. Early formation of sclerotia were noted at the two higher temperatures, but at the lowest temperature, sclerotia formation was delayed or even failure of some cultures to produce sclerotia.

PLATE 12

Comparison on the type of colony produced by Strains V, VI, VII, and VIII at 13–15°C., 28–30°C., and 33–35°C. (14 days old).

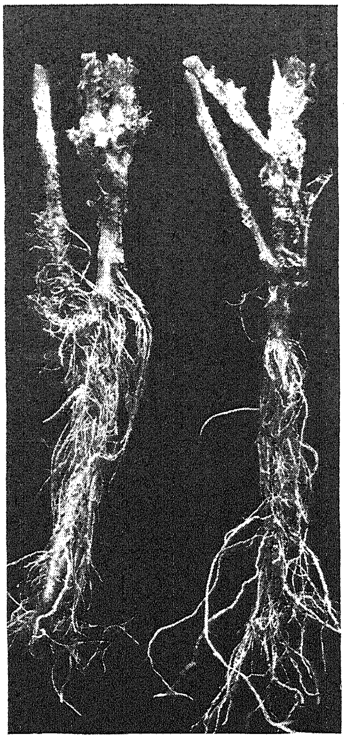
FIG. 1. Strain V at 13–15°C., 28–30°C., and 33–35°C.

2. Strain VI at 13–15°C., 28–30°C., and 33–35°C.

3. Strain VII at 13–15°C., 28–30°C., and 33–35°C.

4. Strain VIII at 13–15°C., 28–30°C., and 33–35°C.

Strains V and VII are similar in growth as those of Strains I, II, III, and IV as shown in Plate 11. Strain VII and Strain VIII differed from the above strains in the type of colony and production of sclerotia. Strain VII produced its sclerotia at 13–15°C., and at 28–30°C., but failed to produce at 33–35°C. Strain VIII failed to produce sclerotia at any of these temperatures.



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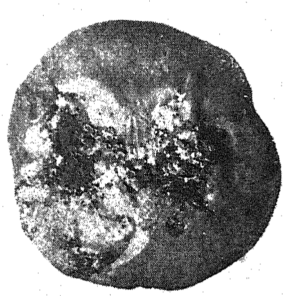

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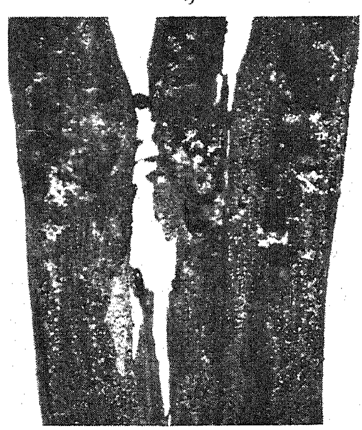

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PLATE 1.

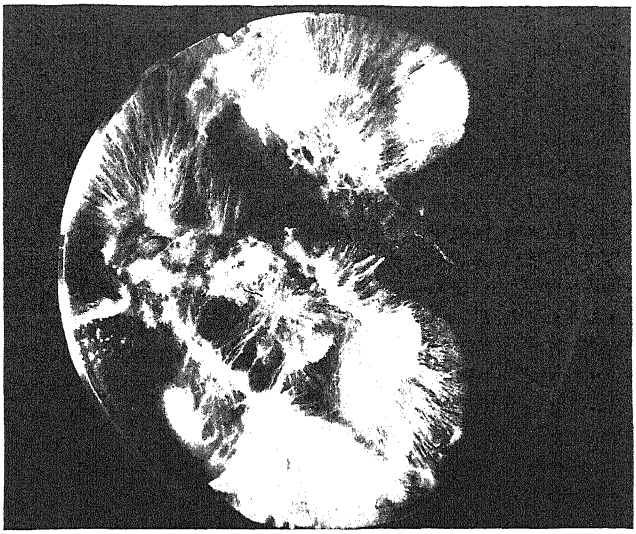

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PLATE 2.

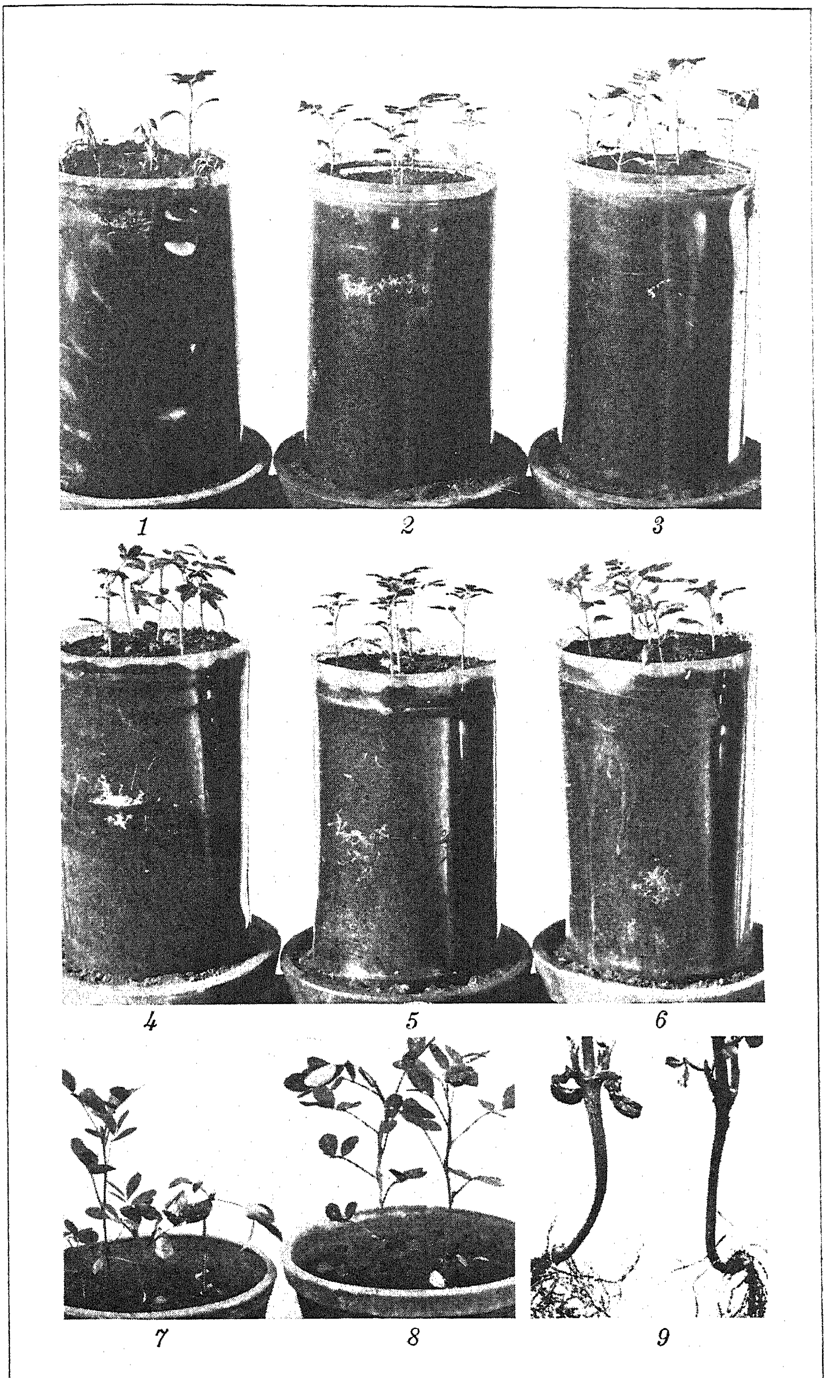

PLATE 3.

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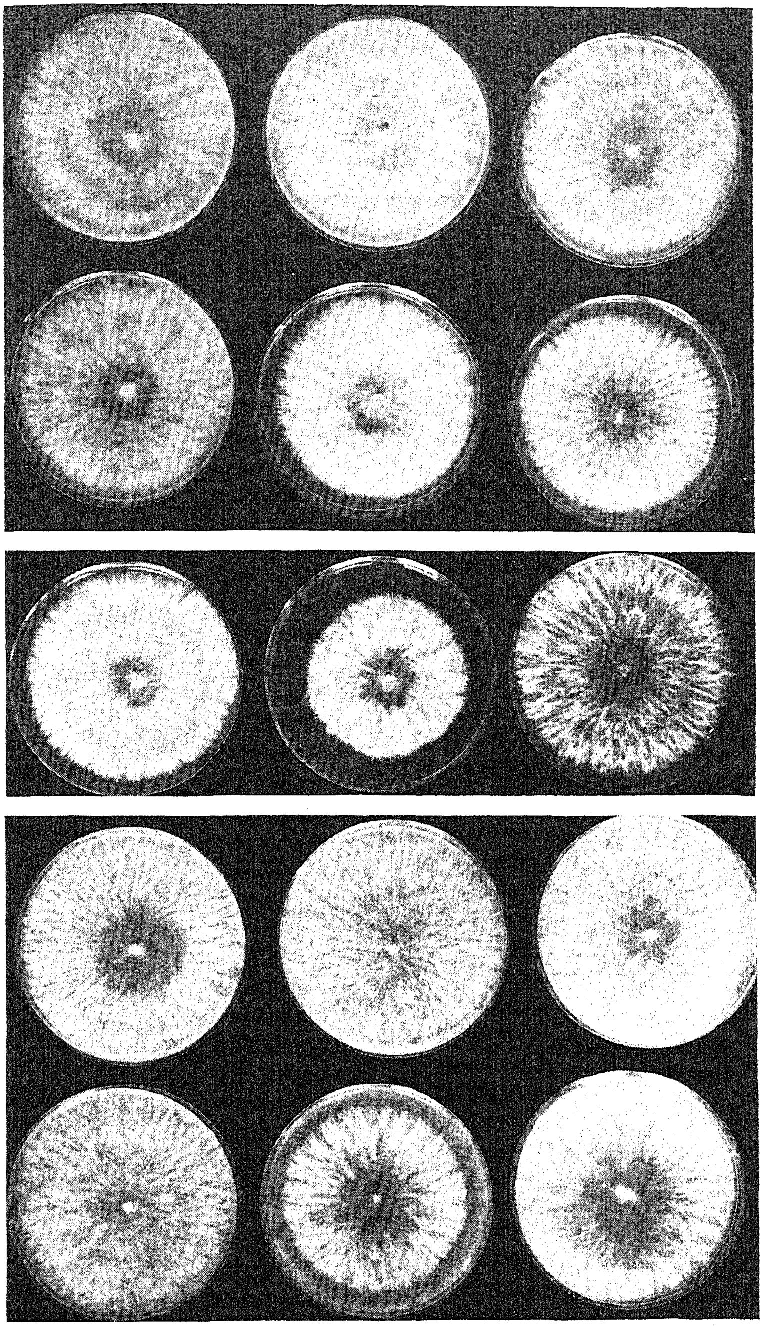

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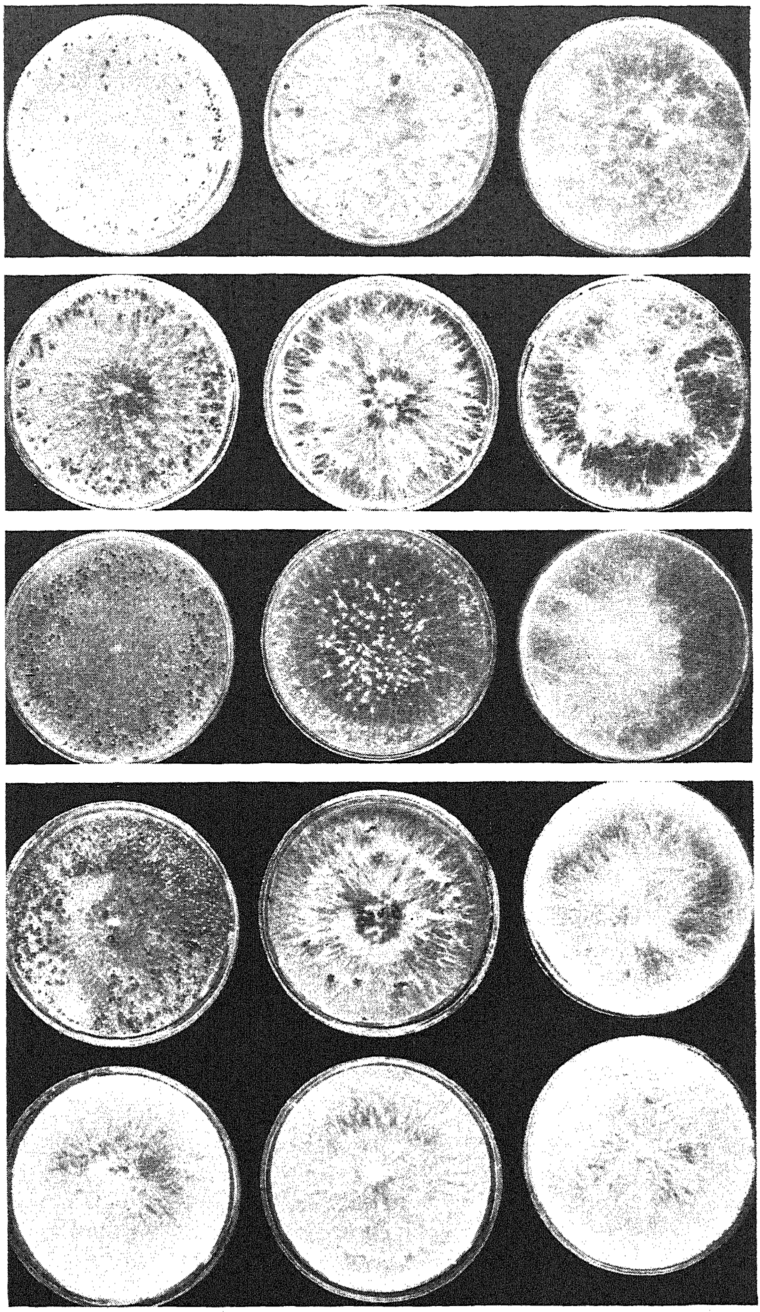

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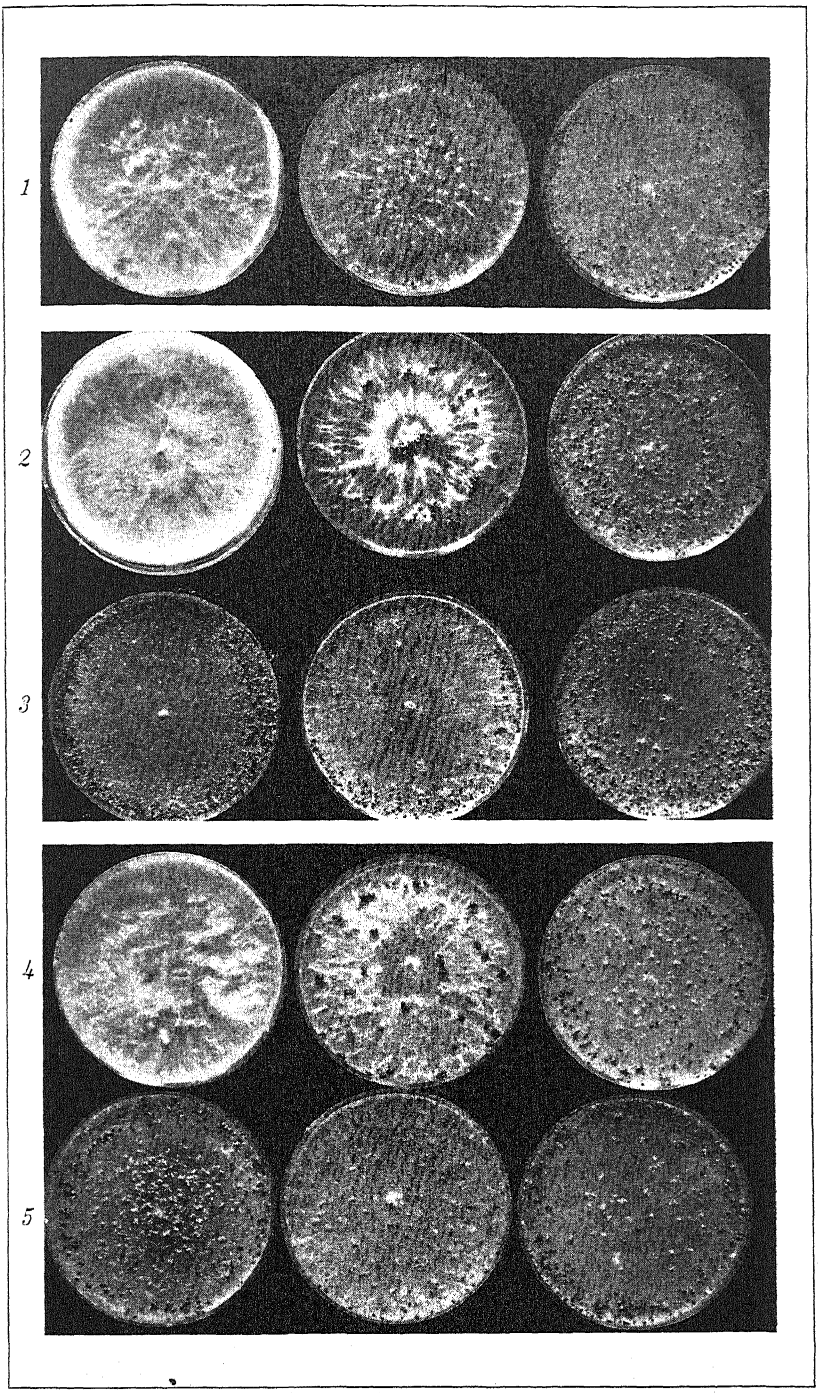

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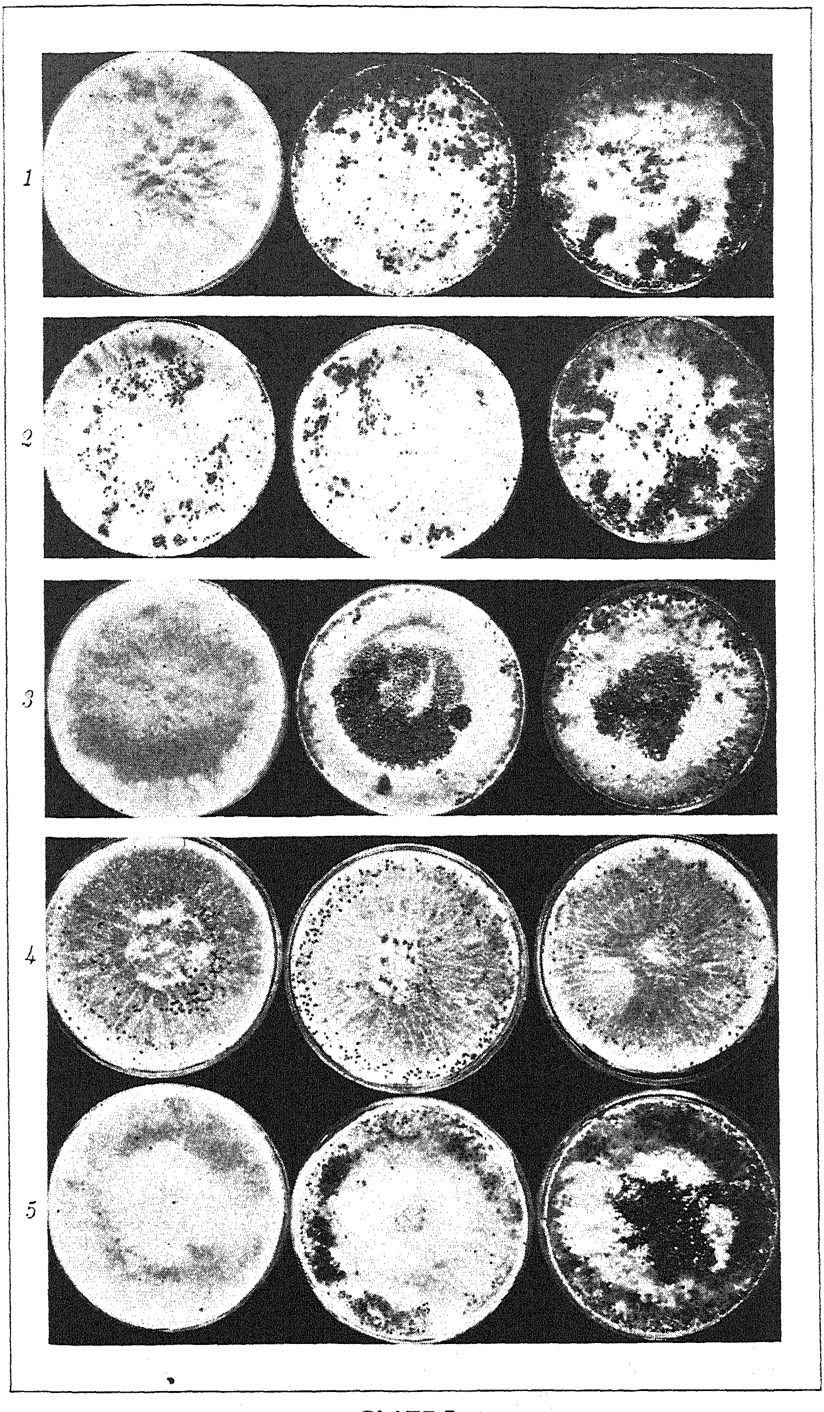

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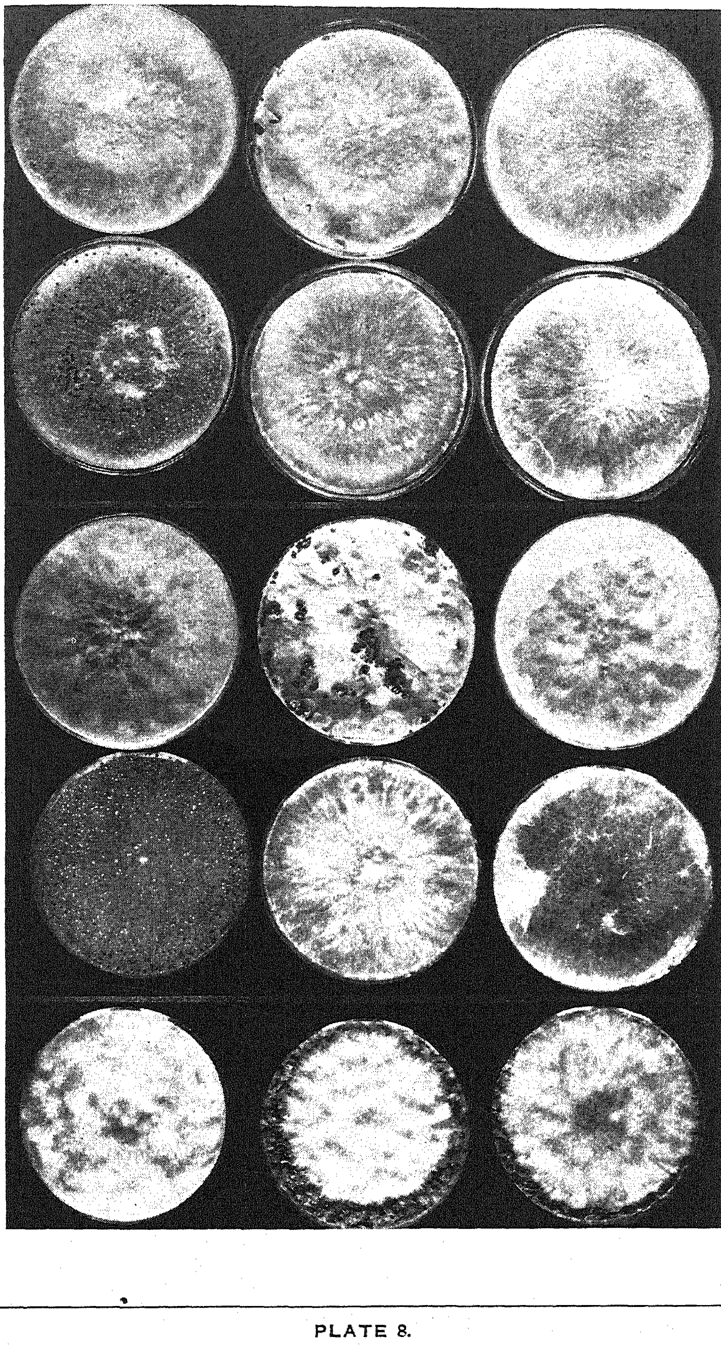

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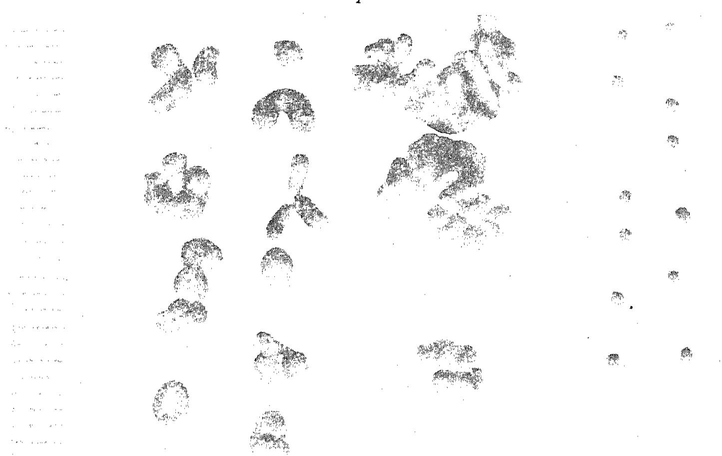

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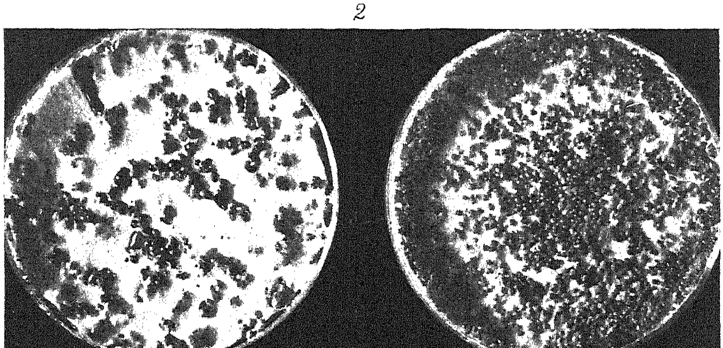

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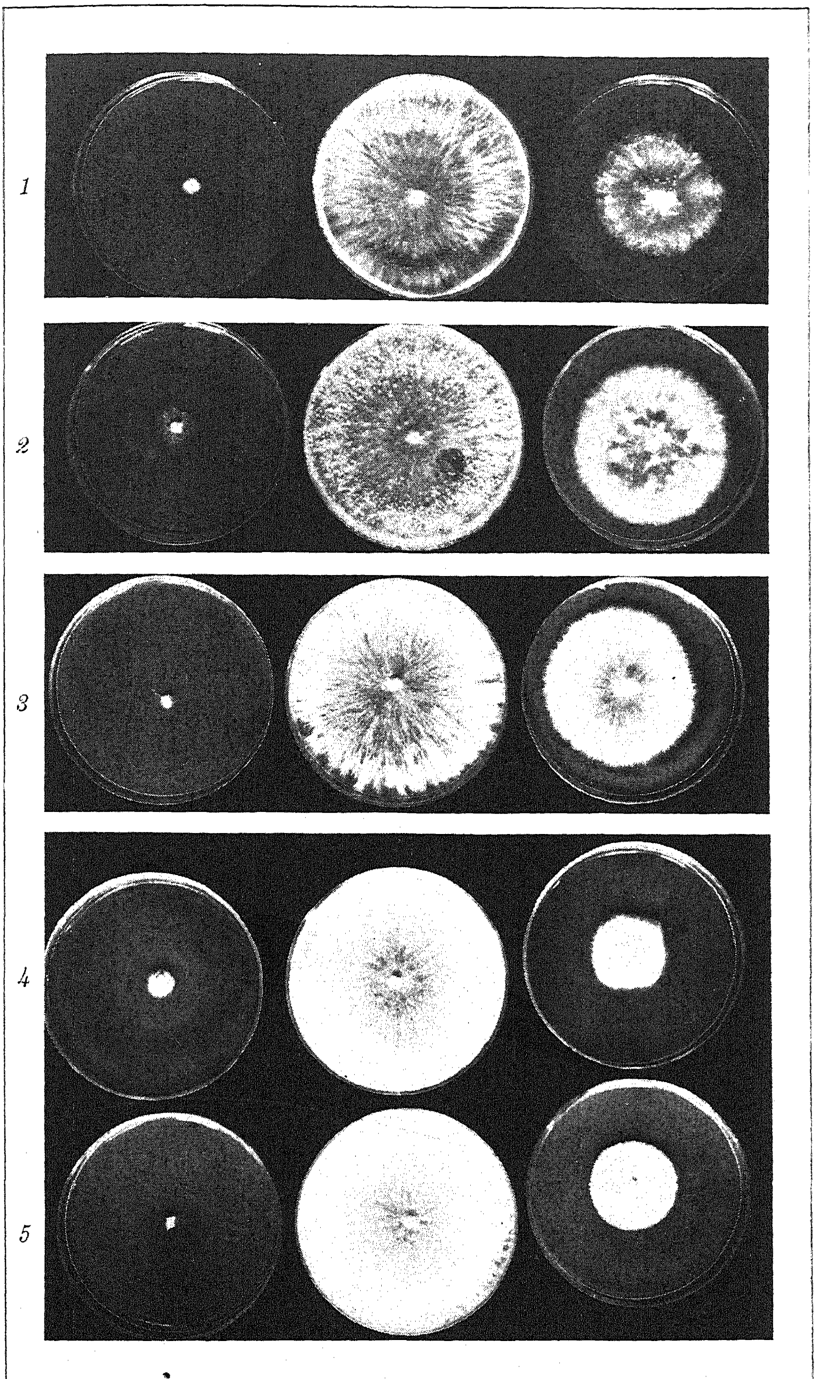

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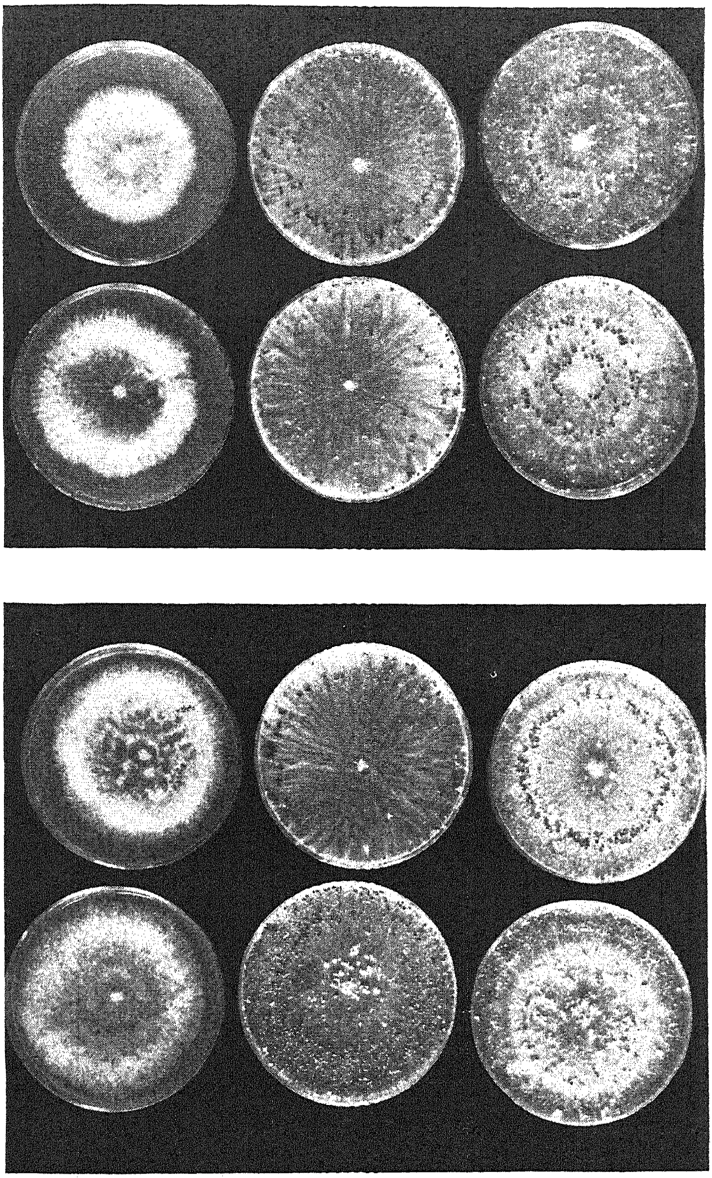

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PLATE 11.

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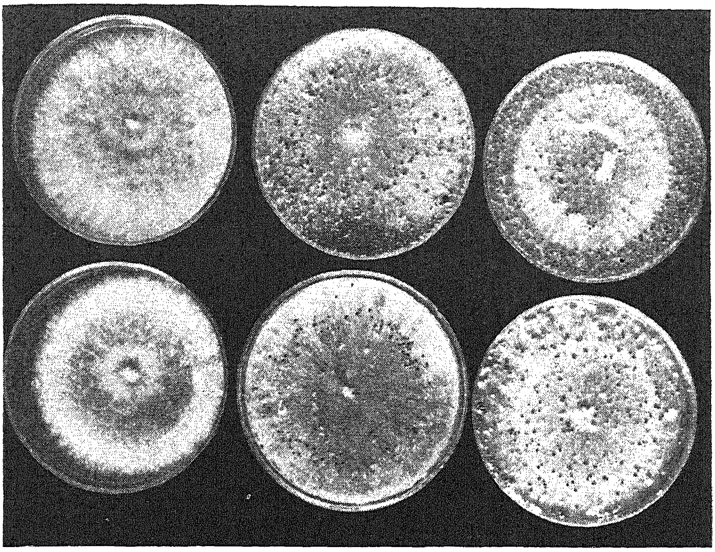

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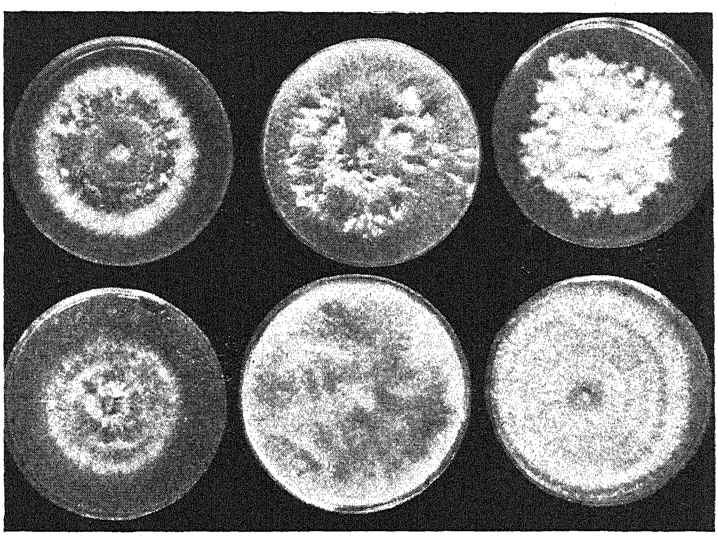

PLATE 12.

FURTHER STUDIES ON THE CONTROL OF LEAF-HOPPERS AND TIP-BORERS ON MANGO INFLORESCENCE

By M. A. PALO and C. E. GARCIA
Of the Division of Plant Pest and Disease Control
Bureau of Plant Industry

SEVEN PLATES

INTRODUCTION

The increasing demand for mango as a dessert and its great possibilities as a profitable export product have directed the attention of mango growers to its production on larger scale. Consequently, one may now see vast mango plantations in Muntinlupa and Novaliches, Rizal, and in some parts of Pangasinan, Batangas, Pampanga, Nueva Ecija, Bulacan, and Cavite. In so raising large-scale plantations, however, the growers have unknowingly opened up convenient fields for the activities of insects and fungi inimical to mango and have encouraged mass attacks from pests to which mango is host. The result is that there are now, not only more numerous species of insects, but also more dangerous ones to fight against than there ever had been. The depredations, particularly of the most insidious mango pests commonly known as leafhoppers and tip-borers, have cause incalculable damage during the last five or six years. In view of the rapidity with which these insects multiply, spread and cause damage to mango blossoms and the apparent helplessness of the growers to stem their ravages, the situation seems to indicate that the objective of increasing mango production cannot be attained by merely planting more trees or extending the area of cultivation and by following all the necessary cultural practices. Rather, it is attained by saving the crop from the depredations of leafhoppers, tip-borer and other serious pests and diseases, barring the effects of unfavorable climate.

In the past few years both the Bureau of Science and the Bureau of Plant Industry received numerous complaints about the menace of the leafhopper and the tip-borer. These complaints, together with inquiries from various mango-growing districts as

to how to control them, show the extent and seriousness of the destructions of these pests. Accordingly, investigations and experiments to develop sprays and spray schedule to check the ravages of these pests were conducted. Some of the sprays developed were so expensive and impractical that they could not in any way make for the yield any commercial profit. Recently, Serrano and Palo (21) reported that the leafhoppers on mango inflorescence can be controlled with common Chinese laundry soap, which is relatively cheap, and readily available locally, by spraying the infested flowers of Carabao and Pico trees, respectively, with 0.5 per cent and 0.4 per cent solutions. Since their work on soap spraying for leafhoppers was only preliminary and had covered but one season of experiments and observation, the necessity for additional experimental work on the same matter is obvious in order to ascertain whether it should be recommended on commercial scale.

Therefore, the purpose of this paper is to throw more light upon our present knowledge of the control of tip-borer and leaf hoppers on mango inflorescence in the Philippines. The results of the present studies on the control of these pests are embodied in a single paper. The main part of these studies was done in Novaliches Mango Plantation and Muntinlupa Plantation, Rizal, from October, 1933, to June, 1935. Supplementary field observations were made in Pasay, Rizal and in Bulacan since 1931.

THE TIP-BORER AND ITS CONTROL

HISTORY AND DISTRIBUTION

Chlumetia transversa formerly known as *Nachaba transversa* Wlk., *Chlumetia guttiventris* Wlk., and *Ariola corticea* Snell. was first described by Walker (25) in 1863. According to Fletcher (4) this insect is generally considered a minor pest of mango in many parts of India. The collection of *Chlumetia transversa* in the British Museum (5) showed that it is also present in Ceylon, Malay Peninsula and in some islands in the East Indies.

The earliest description of considerable harm done by this pest to the young, tender terminal growths of mango in the Philippines was published by Wester (28) in 1920. The pest is widespread in the Philippines and has been reported alarming in many places. An attempt to control this pest in this country was reported by Palo (17) in 1932 in which he obtained a doubtful but encouraging result with the use of lead arsenate in com-

bination with either Bordeaux mixture or lime-sulphur as preliminary spray.

NATURE OF THE INJURY AND ECONOMIC IMPORTANCE

The tip-borer pest, the larva of a moth (*Chlumetia transversa* Walker), is one of the most common insect pests of mango in the Philippines. The insect attacks the mango by boring into the panicles (Plate 1, fig. 1) or young shoots (Plate 1, fig. 2) at or about their tips and then tunneling its way down to the basal part, thereby, causing the tops to shrivel and dry. In all of the mango-growing regions of Luzon this insect has already been known as a dangerous pest and is considered one of the factors responsible for the diminished yearly output of the crop. Palo(17) reported this pest as causing damage from 0.5 to 25.0 per cent of the mango inflorescences in Quingua, Bulacan, in December, 1930, and found it to be equally severe in Muntinlupa, Rizal, in 1931.

Observations on the incidence of this pest in various places during the last four years show that the severity of damage done by this insect to the mango depends upon the age of the infested infloresence and the numerical abundance of the insect. Young panicles bored into by the insect seldom escape death but older inflorescences attacked by the same pest usually show unharmed lower laterals which may continue to develop the fruits. In one instance the present writers recorded 90 per cent tip-borer infestation on one tree, and in another 73.0 per cent with 44.0 per cent dead panicles in the Novaliches Mango Plantation. Since many of the infested inflorescences continue to develop the fruits, some growers believe that the pest is not so harmful as to warrant any serious attention as regards its control, without considering the fact that the injury somehow weakens the inflorescences and reduces their vitality. Owing to its widespread outbreak in the Philippines and the more or less serious injury that it causes to the mango flowers, the tip-borer pest is ranked with the factors of some economic significance in the mango industry and is, therefore, one of the problems to consider in solving mango failure.

SEASONAL ACTIVITIES

Periodic field observations on the destructiveness of the tip-borer pest were started in 1931 in Muntinlupa and Pasay, Rizal, and were continued up to 1935. Monthly observations (Table 1)

TABLE 1.—*Monthly observations on the prevalence of tip-borer (Chlumetia transversa) at Novaliches Mango Plantation*

Year	Month	Number of trees ex- amined	Number of shoots or pani- cles examined per tree	Tip-borer infestation		Remarks
				Range	Average	
				Per cent	*Per cent*	
1933	October	18	120 panicles	2.0–90.0	28.4	On off-season flowers produced by smudging.
	November	20	200 panicles	5.0–80.0	31.7	Do.
	December	35	200 panicles	11.0–44.0	24.8	Do.
1934	January	46	200 shoots	11.5–28.0	17.7	On new leaf shoots.
	February	56	200 shoots	9.5–28.5	16.8	Do.
	March	20	200 shoots	0.0– 4.5	1.6	On normal season flowers.
	April		100 panicles		Negligible	Do.
	May		100 panicles		Nil	No leaf shoots, no flower.
	June	20	20 shoots	1.0–22.5	10.7	On new shoots produced by a few trees.
	July				Negligible	Do.
	August				Nil	No leaf shoots, no flower.
	September				Nil	Do.
	October				Nil	Do.
	November				Nil	The few flowers produced by smudging this month showed no infestation.
	December				Nil	Do.
1935	January	50	200 panicles		Negligible	First wave of flowering. Many trees produced flowers but practically no infestation was observed.
	February	50	200 panicles		Do.	
	March	50	200 panicles		Do.	
	April	50	200 panicles	5.0–12.0	7.0	Second wave of flowering.
	May	50	200 panicles	2.0– 6.0	5.0	Third wave of flowering. ('Flowers and leaf shoots').
	June	20	120 shoots	0– 3.0	1.2	On new leaf shoots.

on the prevalence of this pest in Novaliches Mango Plantation were also made from October, 1933, to June, 1935.

The tip-borer pest was found active only when the trees were in leaf or flower flush. Its destructiveness appears to be influenced to a certain extent by climatic conditions. It has been observed to be highly destructive to the shoots and flowers (off-season) produced during the months of October, November, December, and January. The flowers and shoots produced during the warm dry months (February, March, and April) are usually not seriously attacked. The infestation on the young shoots produced during the rainy months (July, August, and September) are occasionally serious. Storms and strong typhoons apparently affect adversely the tip-borer population as evidenced by the almost complete absence of the insect on flowers and young shoots produced during December, 1934, and January, February and March, 1935, following the terrific storms which lashed the central provinces of Luzon in mid-October and mid-November, 1934, and which blew down almost 90 per cent of the mango trees in Novaliches Mango Plantation.

Considering the length of tip-borer generation as extending from the time the eggs are deposited until the eggs from the progeny are laid, in Novaliches Mango Plantation, there may be as many as four or more generations. In cases where flowering continues from October to April or where the production of new leaf flushes overlaps, tip-borer infestation may always be observed and the generations correspondingly overlap one another.

The habits of this insect during the months when there are neither flowers nor leaf shoots are not known. It is believed that it can live also on plants other than mangoes but a search for such plants was unsuccessful. The absence of the insect during a prolonged period of 3 or 4 months when sometimes no shoot or flower is produced indicates that perhaps it aestivates in certain inconspicuous places or lives on some other hosts.

LIFE HISTORY AND DESCRIPTION OF CHLUMETIA TRANSVERSA

Methods of study.—The life history of *Chlumetia transversa* was studied from January to May, 1934, in the Novaliches Mango Plantation, Novaliches, Rizal, owned by Dr. Nicanor Jacinto but temporarily being used by the Bureau of Plant Industry for experimental work. It was thought at first that this work could be started from the adults reared from cultures in battery jars but the moths obtained would not copulate when released

in insect cages containing young mango inflorescences and tender shoots to which either water or dilute solution of honey or sugar was sprayed as feed.

Several mango leaf buds in a number of trees were then tagged and were examined daily, morning and afternoon, with the aid of a magnifier for the presence of eggs. The shoots on which eggs were deposited were collected and brought to the laboratory in the plantation house. Each shoot, with leaves removed, was placed in a test tube (1.6 cm. diameter by 15 cm. long) containing a layer of soil, about 3 centimeters thick, at the bottom. The test tube was plugged with loose cotton and then labelled. Daily observations, morning and afternoon, on hatching of the eggs were made. The larva obtained was reared in the same test tube by giving it a fresh, young, tender shoot or flower stem which it bored later. The life history work ended with the emergence of the moths from their pupal stage.

Egg.—The eggs (Plate 2, fig. 1), which are laid singly on the young panicle or shoot, are frequently found imbedded in droplets of milky fluid which is perhaps an excretion of the female. They are creamy white, ellipsoidal, about 1.2 millimeters long and 0.74 millimeter thick. When the eggs are about to hatch they turn light brownish. They hatch in from 3 to 7 days or an average of 4.1 days (Table 2).

TABLE 2.—*Life history of tip-borer* (*Chlumetia transversa*)

Culture number	Incubation period	Larval stage	Pupal stage	Life history from egg to adult
	Days	*Days*	*Days*	*Days*
1	5	7	12	24
2	5	12	13	30
3	5	7	16	28
4	7	7	12	26
5	7	10	13	30
6	3	10	13	26
7	3	10	14	27
8	4	8	12	24
9	3	10	13	26
10	4	9	15	28
11	3	8	8	19
12	3	8	9	20
13	4	8	15	27
14	4	9	15	28
15	4	11	15	30
16	3	12	17	32
17	3	9	15	27
Average	4.11	9.11	13.35	26.58

Larva.—The newly-hatched larva (Plate 2, fig. 2) is light brownish, about 1.5 millimeters long and 0.8 millimeter thick. It is cylindrical and tapering at both ends with one short hair set laterally on each abdominal segment. The head is oval, dark brown with a distinct frontal suture. The thorax is about 0.12 millimeter long. The prothorax is chitinized at pronotum and is almost as long as either the mesothorax or metathorax. The abdomen is about one millimeter long and consists of 9 segments which are all of practically the same length except the one adjacent to the caudal plate.

The full grown larva (Plate 2, fig. 3) is about 10.2 millimeters long and 2.5 millimeters thick and is light purple at dorsal surface and pale yellow at ventral side. With the exception of its bigger size, it looks similar to the newly hatched larva. The different larval instars could not be determined because the exuviæ could not be found in the tunnel and among the excreta of the larva. It is believed that the larva eats up its exuvia. The larval life covers a period of from 8 to 12 days or an average of 9.1 days (Table 2).

Pupa.—Before pupation the larva crawls upon the branch and trunk down to the base of the tree. The insect pupates in the soil near the base of the tree. The present junior author at one time picked several of these pupæ from the soil near the base of a mango tree and after rearing them in the laboratory for a few days the adults that emerged were in all cases *Chlumetia transversa.*

The pupa (Plate 2, fig. 4) is light brown, about 8.4 millimeters long and 2.5 millimeters in diameter at its thickest part. The head is oval with genæ broadly expanded and frons reduced. The antennæ are filiform, about 5 millimeters long. The thorax is about 3.2 millimeters long. The prothorax is coarsely punctate with a ridge at the middle and is about one-third as long as the thorax. The wing pads occupy the first four abdominal segments and are about one-half as long as the body. Under laboratory conditions the pupal stage covers a period of from 8 to 17 days or an average of 13.35 days (Table 2).

Adults.—The male (Plate 2, fig. 5) is grayish-black with a wing spread of about 16 millimeters. The forewings are crossed by wavy black lines at basal, subbasal, medial, and discal parts and a row of linear black spots at the margin. The hindwings are pale brownish. The body is about 8 millimeters long. The head is grayish. The antennæ, which are each about 5 milli-

meters long, are filiform with a hair-like projection at each segment. The thorax is about 2.5 millimeters long. The abdomen is about 4.5 millimeters long with a small black crest on from the second to the fourth segment.

The female (Plate 2, fig. 6) is about 10 millimeters long, with a wing spread of about 18 millimeters. It is similar to the male in all body characters except that it does not have the black crest on the abdominal segments.

SPRAYING FOR TIP-BORER WITH LEAD ARSENATE

When to spray for tip-borer.—Since the damage is done by the insect while inside the panicle, it appears that control by spraying with stomach poison is of no use. In observations made by the present junior author in the Novaliches Mango Plantation it was found that the newly-hatched larvæ feed for some time outside the panicle upon soft, tender tissues before it starts to eat up its way into the flower-stem. This interval between hatching of the egg and the entrance of the caterpillar into the panicle offers the best opportunity to kill the pest by means of the stomach spray. The insect may also be killed by the spray when it comes out from the infested inflorescence to attack a fresh panicle. In subsequent spraying experiments aimed to control the tip-borer, the application of the poison was so adjusted as to cover the period of vulnerability in the larval life of the insect.

Materials and methods.—Three series of spraying experiments, in which 0.5 per cent lead arsenate (Orchard Brand) was used to control the tip-borer pest on off-season flowers, were conducted in Novaliches Mango Plantation. The first and second series were performed in November and the third, in December, 1933. The lead arsenate spray was applied at different regular intervals beginning when the panicles were usually about 2 to 6 centimeters long.

In the first series lead arsenate was applied only to half crowns of seven trees leaving their other halves unsprayed as checks. Three of the trees were sprayed 2 times at six days' interval and the remaining four trees, 3 times at 3 days' interval. In the second series sixteen trees were used, the first four were sprayed 3 times at 3 days' interval; the second four, 3 times at 4 days' interval; the third four, 2 times at 6 days' interval; the fourth four, were left unsprayed as checks. In the third series twenty-six trees were used, 13 were sprayed 3 times at 3 or 4 days' interval and the other 13 were used as checks. The results of

these spraying experiments are given in terms of per cent tip-borer infestation (Tables 3, 4 and 5) which were determined, when the inflorescences were full grown, by recording the number of attacked inflorescences in every 150 to 200 counted.

Discussion of results.—In the first series of spraying experiments (Table 3) it may be seen that there is a marked difference

TABLE 3.—*Results of spraying half crowns of carabao and pico trees for tip-borer with 0.5 per cent lead arsenate*

Treatment	Tree number	Variety	Tip-borer infestation based mainly on 150-200 panicles per tree		Panicles totally destroyed by tip-borer		Average tip-borer infestation		Average panicles totally destroyed by tip-borer	
			Sprayed	Check	Sprayed	Check	Sprayed	Check	Sprayed	Check
Two sprayings, 6 days' interval.	6	Pico	9.60	29.50	1.20	7.30	7.95	39.50	0.7	17.10
	10	Carabao	7.47	16.00	.00	.00				
	14	Do	6.80	73.00	0.93	44.00				
Three sprayings, 3 days' interval.	7	Pico	1.00	39.74	0	5.98	1.53	42.31	0	2.98
	11	Carabao	2.30	40.80	0	0				
	13	Do	1.81	47.70	0	5.70				
	16	Pico	1.01	41.00	0	0				

in tip-borer infestation between the sprayed and check halves. Assuming that the distribution of the insect is uniform in each of the trees used in this series, spraying with 0.5 per cent lead arsenate had, therefore, reduced tip-borer infestation on the average from 39.50 to 7.95 per cent on halves sprayed two times at six days' interval and from 42.31 to 1.53 per cent on halves sprayed three times at three days' interval. Correspondingly, the percentage of panicles totally destroyed by the tip-borer pest is higher on the check halves than on sprayed halves. The three-spray schedule at three days' interval gave a more satisfactory control than the two-spray program at 6 days' interval.

In the second series of experiments (Table 4) a much reduced tip-borer infestation was shown by lead arsenate-sprayed trees. No significant difference is, however, noted between the results given by the three-spray schedule at 3 days' interval and the three-spray schedule at 4 days' interval, the slight difference being in favor of the first program. As in the first series, the results obtained from two-spray program in this series were not as satisfactory as those obtained from any of the other two spray schedules. In all cases, however, lead arsenate sprayings

TABLE 4.—*Results of spraying carabao trees for tip-borer with 0.5 per cent lead arsenate at different intervals*

Treatment	Tree number	Tip-borer infestation based on 150-200 panicles per tree	Panicles totally destroyed by tip-borer	Average	
				Tip-borer infestation	Panicles totally destroyed by tip-borer
		Per cent	*Per cent*	*Per cent*	*Per cent*
Three sprayings, 3 days' interval	5	1.01	0	2.00	0.27
	17	2.00	0.27		
	24	3.20	0		
	29	1.80	0.81		
Three sprayings, 4 days' interval	2	1.60	0	2.70	0
	9	2.27	0		
	26	2.30	0		
	27	3.26	0		
Two sprayings, 6 days' interval	4	5.43	0.58	5.43	0.57
	12	6.30	0.97		
	19	4.10	0.76		
	30	5.90	0		
Check	18	19.10	4.04	30.66	6.07
	21	42.17	7.40		
	23	23.80	2.27		
	31	37.60	10.60		

have shown some beneficial effects in reducing the volume of tip-borer infestation.

Since it has been clearly demonstrated in the first and second series that the three-spray schedule at 3 or 4 days' interval gave better results than the two-spray schedule at 6 days' interval, it was, therefore, logical to follow either one of the first two schedules in succeeding experiments. In the third series it was intended to follow the three-spray schedule at 3 days' interval but owing to interruptions caused by rains, the regularity of days of application could not be maintained faithfully; hence, the schedule was made either 3-day followed by the 4-day or a 4-day followed by 3-day interval. In this series tip-borer infestation was reduced from 25.92 to 4.76 per cent (Table 5).

From the foregoing studies it is shown that the best time to spray for tip-borer coincides with the period when the flowers, being still closed, show some resistance to the toxic action of the lead arsenate. Mango flowers, when open, had been observed to be sensitive to the toxic action of lead-arsenate spray. The first application of lead arsenate spray in the three-spray schedule was intended for the early brood larvæ while the third for the late brood larvæ. In the two-spray schedule the first ap-

TABLE 5.—*Results of spraying tip-borer with 0.5 per cent lead arsenate 3 times at 3–4 days' interval*

Treatment	Tree number	Variety	Tip-borer infestation based on 150-200 panicles per tree	Panicles totally destroyed by tip-borer	Average: Tip-borer infestation	Average: Panicles totally destroyed by tip-borer
			Per cent	*Per cent*	*Per cent*	*Per cent*
Sprayed	3	Carabao	8.0	0	4.76	0.26
	6	do	9.5	0		
	11	do	1.0	0		
	12	do	3.5	0		
	17	do	5.5	3.0		
	18	do	6.5	0		
	19	do	5.0	0		
	23	do	4.5	0		
	24	do	2.0	0		
	30	do	5.0	0		
	34	do	2.0	0		
	35	Pico	1.0	0		
	40	do	8.5	0.5		
Check	4	Carabao	23.0	3.0	25.92	1.23
	5	do	33.0	0		
	7	do	29.0	0		
	8	do	16.0	0		
	13	do	26.0	3.0		
	14	do	27.0	2.0		
	15	do	37.0	4.0		
	27	do	20.0	2.0		
	29	do	20.0	0		
	39	do	15.0	0		
	41	Pico	19.0	0		
	42	Carabao	44.0	2.0		
	43	do	28.0	3.0		

plication was aimed at the early brood larvæ and the second at the late brood larvæ.

As a measure of tip-borer control, spraying the mango inflorescences with 0.5 per cent lead arsenate for three times at intervals of 3 or 4 days is beneficial. In commercial mango orchards where leafhopper infestation is very severe, it appears, however, that this treatment will be of no practical value in increasing the crop unless a satisfactory remedial measure against the leafhoppers is found.

PRUNING INFESTED SHOOTS AND INFLORESCENCES

The clean-culture method followed in modern orchards of other countries for the elimination of pests and diseases should be adopted in mango plantations in the Philippines. With reference to the control of tip-borer, this should include detection, collec-

tion and destruction of infested flowers and shoots. In this particular case the coöperation of all the growers in the community is necessary since it is impossible to stamp out the pest if all of the possible sources of infestation in a locality are not eliminated. Detection for the presence of this pest should be done only when the trees are either in leaf or flower flush. The infested terminal growth should be cut out with a tree pruner as soon as detected and then the larva, destroyed. Pruning of infested inflorescences should be done only when the trees show light infestation. If there is an indication that the infestation will be severe, lead arsenate spraying may be resorted to in order to reduce the harm that will be done by the pest. The inflorescences that will show the tip-borer after spraying should also be pruned and the larva inside, killed.

The value of clean-culture in connection with the control of tip-borer, twig-borer and various other insect pests and diseases should not be underestimated. Their elimination by this method may not be rapid but it is one of the best ways of helping to prevent their rapid multiplication and spread. This method should include also the prompt elimination of unnecessary trees, bushes, and shrubs, grasses and weeds which may harbor the mango pests.

NATURAL ENEMIES

Since the tip-borer pest is inside the shoot or panicle during the greater part of its larval life, it appears that it is concealed from its natural enemies. This does not prove to be the case, for the larva of this pest was found parasitized by *Chelonus* sp.,[1] (Plate 2, fig. 7) a grayish-black hymenopterous insect. Evidence pointing out to this parasitism was shown when several adults of the parasite were found in the cheese-cloth-covered culture jar, a few days after several infested young mango shoots containing the larvae of the tip-borer pest had been placed in the jar. The effectiveness of this parasite had not, however, been investigated.

CONTROL OF LEAFHOPPERS

PREVIOUS WORKS ON THE CONTROL OF MANGO LEAFHOPPERS

In India.—The leafhopper pests on mango inflorescence first attracted great interest in India where three species were recognized and identified in 1889 by Lethierry(13) as *Idiocerus ni-*

[1] Determined by Mr. F. Q. Otanes, Assistant Chief of the Plant Pest and Disease Control Division, Bureau of Plant Industry, Manila.

veosparsus,[2] *Idiocerus clypealis* and *Idiocerus atkinsoni*. One of the earliest attempts to control these insects was made in 1888(?) by Gollan of the Botanical Gardens at Saharanpur, who, according to Distant(3) used mixtures of soap, tobacco, sulphur, kerosene diluted with milk, etc., upon the pests but without beneficial results. Hartless(6) states that the most troublesome pest in Northern India is a species of *Idiocerus* for which control he suggested spraying with crude oil emulsion during its nymphal stages. Ballard(1) claimed to have obtained successful results in his spraying experiments at Varagambady, Madras Presidency in which he used crude oil emulsion and fish-oil soap against *I. niveosparsus*. The remedial measures prescribed by Madan Mohan Lal(14) for hoppers in Northern India are increasing the vitality of trees by thinning out groves and breaking up of soil surface around the roots, and five sprayings of fish-oil resin soap (1 lb. of fish-oil resin soap to 15 gallons of water) from February to March. A pre-blossom spraying of fish-oil resin soap was found by Subramania(22) to be fairly effective against the three species found in South India. Resin with a strong contact poison such as solignum or crude oil emulsion was claimed by Husain and Pruthi(7) to be the most effective winter spray for hoppers in Punjab. Spraying with resin wash was also reported by Bhasin(2) to have given good results. Finding no simpler remedy than spraying against the hoppers, Kannan(9) suggested that sacrificing the crop when blossoming is poor may prevent the insects from being carried over from one year to the next. Later on, the same author(10) reported that dusting infested trees with pyrethrum two or three times at intervals of a week is effective in killing the hoppers. Husain(8) tested various insecticides against *I. atkinsoni* and *I. clypealis* and found that only calcium cyanide dusts gave good results. Ramachandra Rao(19) found that a preliminary spray with Bordeaux mixture followed by fish-oil-resin soap and then by lead arsenate was effective in reducing the damage done by mildews, hoppers and caterpillars to the mango flowers. Kannan(11) and Subramaniam(23) reported that an extract of a plant, *Mundulia suberosa*, the active principle of which is rotenone, is effective against the mango hoppers. The latter author claimed that 0.5 per cent extract of the plant gave 100 per cent control of the nymphs after 24 hours.

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[2] This insect more appropriately belongs to the genus *Chunra* rather than to *Idiocerus*, according to Dr. G. Merino, Chief of Plant Pest and Disease Control Division, Bureau of Plant Industry, Manila.

In Dutch East Indies and Formosa.—Leefmans[12], Perriere[18] and Van Hall[24] reported the presence of *I. niveosparsus* on mangoes in Dutch East Indies and Schumacker[20] mentioned the prevalence of both *I. niveosparsus* and *I. clypealis* on mangoes in Formosa in his studies of the Homopterous Fauna of this island but no available literature on the control of these insects was found for these two regions.

In the Philippines.—The records of the Philippine National Museum showed that *I. clypealis* and *I. niveosparsus* were collected and identified as such by C. S. Banks in 1905 and 1909, respectively, but nothing was mentioned about the importance of these pests. The earliest description of serious leafhopper damage to mangoes in the Philippines was given by Wester[26] in 1911 for which control he[27] suggested later to follow the one recommended by Ballard[1] at Madras. Otanes[16] tried the common laundry soap and pyrethrum powder and found them to be deadly to the mango hoppers. Merino[15] reported that light-trapping and dusting with pyrethrum were found very effective in controlling mango hoppers and caterpillars. Nicotine soap was also reported by him to be deadly to the nymphs of the hoppers. Palo[17] in spraying experiments conducted in Muntinlupa, Rizal, to control mango hoppers, tip-borers and anthracnose found that a preliminary spray of either strong Bordeaux mixture-lead arsenate or lime sulphur-lead arsenate followed by nicotine soap, gave profitable results. In a more extensive spraying experiment in which soap or nicotine soap was used, Serrano and Palo[21] reported that successful results were obtained when either of the sprays was applied to the nymphs of the infested flowers 4 to 5 times at intervals of 3 days.

LEAFHOPPER POPULATION OF NOVALICHES MANGO PLANTATION BEFORE THE SPRAYING INVESTIGATIONS WERE STARTED

Before the spraying experiments were started in Novaliches Mango Plantation in October, 1933, a rough estimate of the abundance of the leafhoppers was made by counting in four different directions of the crown of a mango tree, without agitating the leaves, the number of hoppers found within an area of about a square meter. Of the 108 trees examined in different parts of the plantation, the present writers found that the leafhopper population per square meter of crown was on the average 2.49 *I. clypealis* and 0.048 *I. niveosparsus.* Computing from

these data, therefore, a tree with 70 square meters of crown [3] should have leafhopper population of 174.0 *I. clypealis* and 3.36 *I. niveosparsus*. Owing to the difficulty of observing for the leafhoppers, since many of them flew away when approached, these figures were considered lower than their actual number per tree. With these low figures, it would be a surprise to anyone why the few trees which produced flowers in the early part of the next month (November, 1933) were severely infested. The only explanations that could be offered are, firstly, that the flowers attracted most of the leafhoppers from neighboring trees, not to say the four-thousand trees in the whole plantation; secondly, that the climatic conditions during this period appeared to be favorable for reproduction and multiplication of these insects.

SOAPSUDS SPRAYING FOR THE CONTROL OF LEAFHOPPERS ON MANGO INFLORESCENCE

Materials and methods.—Seven series of soapsuds spraying for the control of leafhoppers on mango inflorescence were conducted in Rizal Province, six series in Novaliches Mango Plantation and one series in Muntinlupa Plantation. The soap used in the first six series was obtained from one of the factories in Manila and that used in the seventh series from a factory in Pasay. In all those series of experiments soapsuds of 0.5 per cent and 0.4 per cent concentrations were used, respectively, for the carabao and pico varieties except in the series performed in Muntinlupa Plantation in which 0.4 per cent solution was used for both varieties. In the first six series the soap solution was sprayed on the trees by drenching thoroughly the inflorescences with Deming hand pumps fitted with 15-meter rubber hoses and Bordeaux nozzles tied to 4- to 5-meter bamboo rods and in the seventh series it was applied with one-horse-power sprayer. Spraying the tops of trees was done with the aid of 4- to 6-meter bamboo ladders provided with props. The five-spray schedule at three days' interval originally planned was not carried out faithfully for all trees in each series as sometimes spraying was delayed one to three days because of continuous heavy rainfall, and at times spraying was done as frequently as six or seven times because of heavy reinfestation.

[3] The average tree in Novaliches Mango Plantation has a crown of more or less 70 square meters.

Before the spraying series was started a random examination of the leafhopper infestation was first made by counting the number of adult hoppers on every panicle of each tree. This examination was done during the early part of the egg-laying period of the hoppers when the panicles were about 8 to 10 or more days old. Two to five days later, the panicles were again examined for nymphal infestation by agitating moderately the panicle for about half a minute and then watching for the nymphs. The purpose of the foregoing examination was to determine from the percentage of infested panicles obtained and relative abundance of the nymphs whether the infestation of each tree was light, moderate or severe (Plate 3, fig. 2).

For equitable and impartial comparison between sprayed and unsprayed trees it was thought best to express the results in terms of yield per panicle; for this reason, it was necessary to know the number of panicles and fruits produced by each tree. With the aid of "hand tally counter," counts of the panicles were made before the opening of the flowers and those of the fruits, when they showed signs of maturity. The counts were repeated once if the panicles or fruits were few and twice if abundant. The data obtained were an average of two or three counts.

DISCUSSION OF RESULTS

First series.—This series was conducted in the early part of November, 1933, on flowers produced by smudging in the latter part of the preceeding month. The trees generally showed sparse flowering with tip-borer infestation ranging from 2 to 90 per cent or an average of 28.4 per cent. No spraying for tip-borer was done in this series because it was not thought at first that this pest would be so severe as to require it. Eleven trees sprayed with soap and seven were used as control. The leafhopper infestation which was determined during the early part of the egg-laying period varied from 1.3 to 2.53 *I. clypealis* and from naught to 0.4 *I. niveosparsus* on the average per panicle per tree (Table 6). The subsequent nymphal infestation was 100 per cent *I. clypealis* for all trees and from 2.0 to 54.0 per cent *I. niveosparsus*. The spraying period was marked by heavy rainfall which frequently interrupted the regularity of spraying intervals.

After the fourth spraying a contrast between the sprayed and check trees was observed since the flowers in the sprayed trees looked fresh while those in the check trees appeared

TABLE 6.—*Results of the first series of soapsud spraying for leafhopper nymphs on mango inflorescence*

Treatment	Variety	Number of panicles	Average number of adults per panicle based on 50-70 panicles		Nymphal infestation based on 100 panicles		Yield	Average yield per panicle	Average yield per panicle per tree
			I. niveosparsus	*I. clypealis*	*I. niveosparsus*	*I. clypealis*			
					Per cent	*Per cent*	*Fruits*	*Fruits*	*Fruits*
Sprayed	Pico	88	0	1.92	8.0	100.00	25	0.28	0.308
	Carabao	216	0	1.54	6.0	100.00	125	0.57	
	do	216	0	2.53	2.0	100.00	13	0.06	
	Pico	888	0	2.32	2.0	100.00	199	0.22	
	Carabao	379	0.13	1.55	10.0	100.00	70	0.18	
	do	370	0.4	2.00	44.0	100.00	32	0.08	
	do	227	0.4	1.40	48.0	100.00	87	0.33	
	do	152	0.4	1.80	54.0	100.00	16	0.10	
	do	415	0	2.50	2.0	100.00	82	0.19	
	Pico	363	0.2	1.60	30.0	100.00	285	0.78	
	Carabao	102	0.3	1.80	40.0	100.00	62	0.60	
Check	Carabao	106	0.18	1.50	24.0	100.00	34	0.32	0.222
	do	109	0.11	1.31	7.0	100.00	64	0.58	
	do	150	0	1.80	3.0	100.00	41	0.27	
	do	301	0	1.30	5.0	100.00	46	0.15	
	do	144	0.38	1.74	38.0	100.00	8	0.05	
	Pico	649	0	1.30	2.0	100.00	0	0	
	Carabao	108	0.21	1.60	21.0	100.00	21	0.19	

blighted. During the opening of most of the flowers and beginning with the date of the fifth spraying it rained continuously for three days; so spraying of a number of trees was delayed 2 or 3 days. This delay gave the hopper nymphs from new hatchings the chance to feed constantly for some days on the sprayed flowers which later also withered and turned black. The ruin of the flowers was believed to be due, in part, to the rain which impaired the activity of the pollinating insects so much that many of the flowers remained unfertilized. Anthracnose disease was suspected as one of the factors responsible for the blighting of the flowers because of favorable weather but isolation studies for its causative agent did not reveal its presence. The fruits that developed to maturity were on the average 0.308 a panicle for each sprayed tree and 0.222 a panicle for each check tree (Table 6). As shown in Table 14 a net return of minus ₱3.14 from the sprayed tree and minus ₱2.84 from the check tree was obtained in this series. From the standpoint of control this series was a failure, although on the average the sprayed panicle gave slightly higher yield than the check panicle.

Second and third series.—These two series were conducted simultaneously in December, 1933, on smudge-produced flowers. They were essentially the same except that the sprays were applied to half crowns in the second series and to the entire crowns in the third series. In both series soap spraying for leafhoppers was preceded by lead arsenate spraying for tip-borer. The seven trees used in the second series nearly all showed profuse flowering with tip-borer infestation on the lead-arsenate-sprayed halves reduced to 1.01–9.60 per cent (Table 3). The sixteen trees used in the third series showed moderate and sparse flowering with tip-borer infestation on lead arsenate-sprayed trees reduced to 1.01–6.30 per cent (Table 4).

The trees used in both series were all severely infested by leafhoppers, the predominating species of which was *I. clypealis* (Tables 7 and 8). Five or six sprayings for the hopper nymphs with soap at intervals of 3 days were of no avail in saving the crop from serious damage as shown by the extremely low yield of the treated trees (Tables 7 and 8) in both series despite the profusion of inflorescence on some of those trees. The destruction of the sprayed inflorescence (Plates 4 and 5) was caused by the heavy migration of young adult hoppers from the unsprayed flowers. The young fliers which need plenty of juice for their full development were voracious suckers of sap from the tissues of the inflorescence. Soapsud spray is powerless in

TABLE 7.—*Results of the second series of spraying for leafhopper nymphs with soapsud (soapsud preceeded by lead arsenate)*

Tree No.	Variety	Number of panicles		Average number of adults per panicle based on 100 panicles		Nymphal infestation based on 100 panicles		Yield		Average yield per panicle		Average yield per panicle per half tree	
		Sprayed	Check	*I. niveosparsus*	*I. clypealis*	*I. niveosparsus*	I. clypealis	Sprayed	Check	Sprayed	Check	Sprayed	Check
						Per cent	*Per cent*	*Fruits*	*Fruits*	*Fruits*	*Fruits*	*Fruits*	*Fruits*
6	Pico	185	166	0.06	4.92	1.40	100	13	8	0.07	0.04		
7	do.	860	1,053	0.16	3.10	1.2	100	8	6	0.009	0.005		
10	Carabao	1,026	762	0.31	2.85	62.0	100	9	0	0.008	0		
11	do.	455	746	0.16	2.82	20.0	100	2	2	0.004	0.002	0.038	0.006
13	do.	1,729	1,665	0.08	4.90	20.0	100	10	0	0.005	0		
14	do.	188	166	0.06	2.64	82.0	100	10	0	0.05	0		
16	Pico	520	665	0.29	3.32	25.0	100	6	0	0.01	0		

TABLE 8.—*Results of the third series of soapsuds spraying for leafhopper nymphs on mango inflorescense (soapsud preceded by lead arsenate)*

Treatment	Tree No.	Variety	Number of panicles produced	Average number of adults per panicle based on 100 panicles		Nymphal infestation based on 100 panicles		Yield	Average yield per panicle	
				I. niveosparsus	*I. clypealis*	*I. niveosparsus*	*I. clypealis*			
						Per cent	*Per cent*	*Fruits*	*Fruits*	
Sprayed	2	Carabao	413	0.04	4.18	41.0	100	10	0.02	0.05
	4	do	329	0.08	3.53	29.0	100	11	0.03	
	5	do	581	0.08	5.40	44.0	100	1	0.001	
	9	do	346	0	3.24	14.0	100	52	0.15	
	12	do	337	0.19	3.04	64.0	100	16	0.04	
	17	do	153	0	2.10	6.0	100	6	0.03	
	19	do	407	0.14	3.42	76.0	100	10	0.02	
	24	do	251	0.14	2.04	62.0	100	21	0.08	
	26	do	148	0.02	1.86	24.0	100	12	0.08	
	29	do	467	0.56	2.82	46.0	100	7	0.01	
	30	do	362	0.04	2.89	20.0	100	9	0.02	
	27	do	117	0.02	1.80	4.0	100	15	0.128	
Check	18	do	118	0.20	2.20	19.0	100	6	0.05	0.03
	21	do	446	0.04	1.92	27.0	100	3	0.006	
	23	do	440	0.06	2.44	12.0	100	5	0.011	
	31	do	107	0.34	4.10	45.0	100	6	0.056	

killing them. When the inflorescence in which they were bred, withered and became sapless, they flew to the fresh inflorescence which they also destroyed later. The records of migration of young adult fliers from unsprayed halves to sprayed halves of four trees based on 50 panicles per tree are shown in Table 9. Those records were started when most of the unsprayed inflorescences were withering and while the sprayed inflorescence still showed signs of freshness. During this time the hoppers were fast shedding off their last nymphal skin. In Table 9, it will be seen that on December 20, the records started with an average of 48.2 young adults on the check flowers and only 2.2 young adults on the sprayed flowers; then the figures rose on December 23, to 231 for the unsprayed and 78.7 for the sprayed; finally, they went down on December 30 to 1.9 for the unsprayed and 9.2 for the sprayed, showing that the hoppers had dispersed and had moved in various directions to other trees. From these observations, it would not, therefore, be advisable to use many check trees in spraying experiments for leafhopper control because they make good sources of reinfestation for the sprayed flowers. These two series of experiments were also a total failure. According to Table 14 an average net return of minus

TABLE 9.—*Showing the rate of migration of young adult leafhoppers from the unsprayed to sprayed inflorescences of four trees used in the fourth series and also their dispersion when both sprayed and unsprayed flowers withered and became sapless (based on 50 panicles per tree).*

Tree No.	December 20		December 23		December 27		December 30	
	Check	Sprayed	Check	Sprayed	Check	Sprayed	Check	Sprayed
	Leaf-hoppers	*Leaf-hoppers*	*Leaf-hoppers*	*Leaf-hoppers*	*Leaf-hoppers*	*Leaf-hoppers*	*Leaf-hoppers*	*Leaf-hoppers*
7	41	2.5	231	78	18.6	47.8	1.2	10
10	68	2.0	242	67	17.5	51.0	2.3	7
11	52	2.5	253	109	41.0	103.0	1.4	12
13	32	1.8	198	61	26.5	42.7	3.0	8
Average	48.2	2.2	231	78.7	25.9	61.1	1.9	9.2

₱7.89 was obtained from a sprayed tree and minus ₱3.78 from a check tree.

Fourth and fifth series.—These two series were conducted simultaneously in January, 1934, on smudge-produced flowers. The trees used in these two series showed profuse, moderate and sparse flowering. The trees in the fourth series, not being sprayed for tip-borer showed 26.0 per cent infestation while those in the fifth series, being sprayed for tip-borer with lead arsenate showed on the average only about 4.7 per cent infestation. The infestation by the leafhopper nymphs, of which the preponderant species was *I. clypealis*, was severe (Tables 10 and 11).

Five to seven sprayings of soapsuds gave a yield of 0.384 fruit in the fourth series (Table 10) and 0.415 fruit in the fifth series (Table 11) on the average per panicle per tree. The two check trees used for both series yielded only 0.015 fruit on the average per panicle per tree.

A severe fruit-shedding which started from the time the fruits were set to the time they matured had been observed to be one of the causes of the great reduction in the expected yield in both series. According to Table 12 only 1.87 to 5.0 per cent of the fruits left on the panicles a week after setting developed to maturity. Fruit-shedding was caused by various factors. The natural fruit-shedding which is frequently observed on various fruit trees was believed to be due to inadequate nourishment for a great number of growing fruits, as a result of deficient soil nutrition. The shedding of a great number of mango fruits in these two series was due in part to the reinfestation of leaf-

TABLE 10.—*Results of the fourth series of soapsud spraying for leafhoppers on mango inflorescence*

Treatment	Tree No.	Variety	Number of panicles	Average number of adult hoppers per panicle based on 100 panicles		Nymphal infestation		Yield	Average yield per panicle	Average yield per panicle per tree
				I. niveosparsus	*I. clypealis*	*I. niveosparsus*	*I. clypealis*			
						Per cent	*Per cent*	*Fruits*	*Fruits*	*Fruits*
Sprayed	4	Carabao	273	0.89	1.17	20.0	100	66	0.24	0.384
	5	do.	123	0.34	1.85	14.0	100	23	0.18	
	7	do.	580	0.04	2.30	10.0	100	53	0.09	
	13	do.	646	0.02	2.70	4.0	100	104	0.16	
	14	do.	741	0.07	2.64	36.0	100	157	0.21	
	15	do.	560	0.03	2.02	9.0	100	112	0.20	
	20	do.	152	0.10	1.75	32.0	100	85	0.55	
	21	do.	145	0.50	1.82	52.0	100	41	0.28	
	26	do.	174	0.02	1.67	28.0	100	68	0.39	
	27	do.	66	0.01	1.25	6.0	100	31	0.46	
	29		247	0.01	1.95	4.0	100	36	0.14	
	31	do.	2,183	0.32	3.21	30.0	100	1,170	0.53	
	33	do.	190	0.01	2.10	5.0	100	62	0.32	
	37	Pico	640	0.02	1.72	10.0	100	547	0.85	
	38	Carabao	1,627	0.02	2.32	12.0	100	892	0.54	
	41	Pico	143			14.0	100	180	1.25	
	42	Carabao	267	0.03	2.02	12.0	100	79	0.29	
	43	do.	152	0.10	1.75	32.0	100	51	0.33	
	49	do.	72					22	0.30	
Check	10	Carabao	679	0.04	2.90	20.0	100	1	0.001	0.015
	16	do.	1,724	0.21	2.67	32.0	100	63	0.03	

TABLE 11.—*Results of the fifth series of soapsud spraying for leafhoppers on mango inflorescence*

Treatment	Tree No.	Variety	Number of panicles	Average number of adult hoppers per panicle based on 100 panicles		Nymphal infestation		Yield	Average yield per panicle	Average yield per panicle per tree
				I. niveosparsus	*I. clypealis*	*I. niveosparsus*	*I. clypealis*			
						Per cent	*Per cent*	*Fruits*	*Fruits*	*Fruits*
Sprayed	3	Carabao	386	0.21	1.25	38.0	100	244	0.63	0.417
	6	do	385	0.08	4.14	18.0	100	24	0.06	
	11	do	254	0.12	1.70	14.0	100	61	0.24	
	12	do	280	0.03	2.14	14.0	100	89	0.31	
	17	do	1,553	0.02	3.02	8.0	100	552	0.35	
	18	do	2,564	0.06	2.61	24.0	100	1,484	0.58	
	19	do	1,414	0.40	2.01	64.0	100	213	0.15	
	23	do	1,696	0.20	2.55	68.0	100	791	0.47	
	24	do	945	0.27	2.00	36.0	100	501	0.53	
	30	Pico	645	0.60	1.70	72.0	100	608	0.94	
	34	Carabao	779	0.55	3.20	18.0	100	312	0.40	
	35	Pico	1,464	0.21	2.33	32.0	100	621	0.42	
	40	Carabao	957	0.06	1.82	24.0	100	330	0.34	
Check	10	do	679	0.04	2.90	20.0	100	1	0.001	0.015
	16	do	1,724	0.21	2.67	32.0	100	63	0.03	

TABLE. 12.—*Showing the extent of fruit-shedding in some trees used in the fourth and fifth series of spraying experiments for the control of leaf-hoppers*

Tree number	Number of panicles tagged	Number of fruits on 40 panicles a week after setting[1]		Number of fruits left on the panicle after 7 weeks		
		Range	Average	Range	Average	*Per cent*
3	40	1–32	12.00	0–3	0.600	5.00
12	40	1–32	9.00	0–2	0.350	3.90
13	40	1–29	8.35	0–3	0.320	3.80
14	40	1–54	13.60	0–2	0.400	2.94
15	40	1–43	13.20	0–2	0.300	2.27
17	40	1–48	13.20	0–2	0.250	1.89
18	40	2–51	14.55	0–4	0.700	4.80
23	40	1–47	14.72	0–2	0.275	1,87
24	40	1–25	13.00	0–2	0.620	4.76
31	40	1–30	12.40	0–4	0.400	3.20

[1] A week after the mango fruits had set, forty panicles from each tree were tagged and then the number of fruits were counted. After seven weeks the number of fruits on the tagged panicles were counted again to ascertain how many were left on the panicle.

hoppers, and mainly to the combined attack of caterpillars, beetles and fruit-fly maggots. Despite the severe fruit-shedding, the sprayed trees in both series still showed much heavier yield in fruits (Plate 6) than the checks.

Computing for net returns (Table 14), ₱1.46 was obtained from the sprayed trees of the fourth series and ₱6.20 from those of the fifth series while minus ₱2.79 was obtained from the check trees. Although no distinct difference in average yield in fruits per panicle per tree may be noted between the two series (Tables 10 and 11) according to the figures above they differ markedly in financial net returns, being higher in the fifth than in the fourth series. This was probably due largely to the fact that in the fifth series more trees with profuse flowering were used, and also, in part, to the reduced number of tip-borer infested panicles as a result of lead arsenate treatment.

Sixth series.—This series was conducted on smudge-produced flowers[4] in April, 1934, in another part of the plantation about a kilometer away from the place where the first five series were

[4] The normal flowering season of mango ordinarily covers a period of from February to April. Forcing trees to flower by smudging is not usually practiced during this period. Unexpectedly, however, about two-thirds of the trees in the plantation produced the leaf shoots instead of the flower flush in February and March, 1934. A number of those trees with matured leaves were then smudged for a few days and produced the flowers which were used in the sixth series.

performed. No spraying for tip-borer was done in this series because this insect was scarce during this period. Infestation by the leafhopper nymphs was in general moderate.

The five-spray schedule at intervals of 3 days was followed faithfully in this series. As a result of the treatment the sprayed trees showed heavier setting of fruits than the checks but when the fruits were approaching maturity in June, 1934, they were attacked by beetles of various species[5], among which the following were observed to be destructive:

1. *Protaetia bifenestrata* Chevr. } Cetanidæ
2. *Protaetia philippinensis* Fab. } Cetanidæ
3. *Protaetia* spp. (2 kinds). } Cetanidæ
4. *Parastasia canaliculata* West (Scarabaeidae)
5. *Popillia cetrata* Newm. (Scarabaeidae)
6. *Phytorus lineolatus* Weise (Chrysomelidae)
7. *Monolepta bifasciata* Hornst. (Chrysomelidae)

The beetles attacked the fruits by eating up portions of the rind and flesh (Plate 7, figs. 1 and 2). Sometimes two or three species of the beetles were seen attacking a fruit at one time. Owing to the preponderance of *Phytorus lineolatus* it was observed to be more destructive than any of the other species of the beetles. Rot organisms and flies of the genera (*Drosophila* and *Chaetodacus*) followed the attack of the beetles, as a result of which the fruits fell off. Nearly all of the maturing fruits that were shed showed the attack of the beetles. The number of fallen fruits counted were about two times the number actually harvested.

Notwithstanding the severe attack of beetles more fruits were harvested from the treated trees than from the check trees (Table 13). The sprayed trees gave an average yield of 0.49 fruit per panicle while the check trees only 0.10 fruit per panicle. Owing to the low cost of mangoes in June, being only two pesos per *kaing* of 200 carabao fruits and one peso a *kaing* of 300 pico fruits, no profit was realized from this series. As shown in Table 14, a net return of minus ₱1.43 from the sprayed and minus ₱1.43 from the check was obtained.

Seventh series.—This series was conducted in Muntinlupa Plantation from November, 1934, to January, 1935, on smudge-produced flowers. The plantation, was, for the last six years, the focus of severe leaf hopper infestation in the locality. Owing

[5] The species of beetles herein listed were determined by comparing the specimens with those in the National Museum, Bureau of Science, Manila.

TABLE 13.—*Results of the sixth series of soapsud spraying for the control of leadhoppers on mango inflorescence*

Treatment	Tree No.	Variety	Number of panicles	Yield	Average yield per panicle	Average yield per panicle per tree
				Fruits	*Fruits*	*Fruits*
Sprayed	1	Carabao	155	106	0.68	0.49
	5	do	451	340	0.75	
	6	do	122	77	0.63	
	8	do	562	482	0.85	
	9	Pico	180	129	0.72	
	37	Carabao	183	31	0.16	
	39	do	150	42	0.28	
	88	do	154	53	0.34	
	109	do	96	18	0.18	
	127	do	153	58	0.37	
Check	4	do	154	0	0	0.10
	86	Pico	301	63	0.20	

to the strong typhoons which occurred in mid-October, 1934, the leafhopper population of the plantation as revealed by an examination of the foliage of several trees prior to spraying, was sparse. The manager of the plantation insisted on spraying all the available trees in flower with soap, in spite of the light leafhopper infestation shown by an examination of the inflorescences, because he feared that they might be the source of serious infestation for the succeeding normal season crop. Spraying more than 20 trees was then started using 0.4 per cent solution of the soap that was obtained from a factory in Pasay, but it had to be discontinued after the third application at intervals of 3 days because it was observed that the soap spray was injurious to the flowers. The injury was noticed only after an examination of several inflorescences which showed premature withering of the flowers but which had few or no hopper nymphs. It was not known to what properties of the soap the injury could be attributed since in the analysis made by the Chemistry Section of the Bureau of Plant Industry the sample contained practically no free alkali.

All the trees used in this series produced the fruits only on top of the trees which, being about 15 to 20 meters high, could hardly be reached by the spray. This, therefore, could be taken as another indication that the soap used was injurious to the flowers. The yield obtained was on the average about one and one-half "kaings" per tree.

TABLE 14.—*Showing the expenses incurred and net returns obtained in each of the six series of spraying experiments for the control of leafhoppers on mango inflorescence*

Series	Number of trees used		Value of the crop [a]		Total expenses [b]		Average value of the crop		Average expenses		Average net returns	
	Sprayed	Cheks	Sprayed	Checks	Sprayed	Checks	Sprayed	Checks	Sprayed	Checks	Sprayed	Check
			Pesos	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*
First	11	7	17.13	8.56	61.79	28.43	2.47	1.22	5.61	4.06	−3.14	−2.84
Second	12	4	1.64	0.29	70.83	16.02	0.14	0.07	5.90	4.01	−5.76	−3.98
Third	3.5	3.5	6.80	0.80	34.28	14.04	1.90	0.23	9.79	4.01	−7.89	−3.78
Fourth	19	2	132.98	2.56	105.21	8.13	6.99	1.28	5.53	4.07	+1.46	−2.79
Fifth	13	2	202.47	2.56	121.84	8.13	15.57	1.28	9.37	4.07	+6.20	−2.79
Sixth	10	2	12.07	0.21	11.67	0.08	1.25	0.11	2.67	1.54	−1.43	−1.43

[a] The off-season harvests from the first series were sold at ₱8 a *kaing* of 200 carabao fruits and ₱4.50 a *kaing* of 300 pico fruits while the crop obtained from the sixth series was sold at ₱2 a *kaing* of carabao fruits and ₱1 a *kaing* of pico fruits.

[b] Total expenses include the following:

1. Smudging—₱4 per tree in the first five series and ₱1.50 per tree in the sixth series. These figures were obtained from Mr. Sixto Sison, Superintendent of the station.
2. Spraying—
   a. Sprays—lead arsenate, ₱0.52 a kilo, soap, ₱0.23 a kilo.
   b. Labor (5 laborers, four working with two pumps, one supplying water sprayed two trees at a time at ₱4 a day of 9 working hours or ₱2 per tree a day. Expenses for labor were computed from the amount of time spent for spraying).
3. Harvesting—0.25 peso a *kaing* of 200 fruits of the Carabao variety or of 300 fruits of the Pico variety.
4. Transportation—The cost of transportation of mangos to Manila by truck is ₱0.15 a *kaing*.

PHOTOTROPIC RESPONSE OF MANGO LEAFHOPPERS, TIP-BORER AND OTHER INSECTS

The possibility of utilizing light traps for the control of mango leafhoppers was pointed out by Merino(15) in 1929. Serrano and Palo(21) reported positive evidence that these insects are attracted to artificial light. The present knowledge on light-trapping of mango insects in the Philippines is inadequate and the data so far obtained on this were insufficient to encourage the use of light traps for the control of these insects. The observations and data recorded in this paper may add further information to what is already known about this subject.

The following experiments and observations on the phototropic response of mango leafhoppers and other insects were performed in January, 1934, in Novaliches Mango Plantation. It was originally planned in this experiment to use variously colored lights for trapping the insects but since facilities for their installation were inadequate the writers had to resort to the use of only two kinds of lamps with lights of different intensity. Two Coleman incandescent gas lamps each of 300 candle power and two ordinary Dietz lanterns were each placed in a basin containing water to which sufficient kerosene to cover the entire surface of the water was added. A basin containing the Coleman lamp and another containing the Dietz lantern were placed in opposite directions on lateral branches, about six meters high [6] of a tree which showed severe leafhopper infestation. The other pair of lamps was placed in like manner in another severely infested tree. The two lamps in each tree were exchanged places every night. The lamps were lighted at 6 P. M. and extinguished at 5 A. M. A supplementary experiment in which five Dietz lanterns were used as light traps in each of the five mango trees which showed high intensity of leafhopper attack was also conducted. The average daily capture of leafhoppers, tip-borer moths and other insects are shown in Tables 15 and 16.

From the study of Table 15 it is seen that more insects are attracted every night to the Coleman lamp than to the Dietz lantern. As shown by the average capture for a period of from January 9 to January 27 the Coleman lamp attracted more than two times as much *I. niveosparsus* and slightly less than two

[6] For trees about 12 to 15 meters high, light traps set on lateral branches about six meters high had been found previously by trials to capture more leafhoppers than those placed either below this height or on one-meter-high stands several meters away from the tree.

TABLE 15.—*Showing the average daily response of leafhoppers, tip-borrers and other insects to Dietz and Coleman lights*[1] *and to weather factors*

Date (1934)	*I. niveosparsus*		*I. clypealis*		Tip-borer moth		Other moths		Flies and mosquitoes		Hymenoptera		Orthoptera		Coleoptera		Other leaf-hoppers (Homoptera)	
	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C
January 9	114	345	27	31	11	12	38	324	27	41	5	14	7	7	----	----	----	----
January 10	265	388	19	32	8	12	71	247	42	61	11	6	10	13	7	33	9	9
January 11	266	522	74	86	6	5	85	94	166	180	5	8	13	12	4	9	7	8
January 12	21	29	12	14	7	7	98	131	57	72	6	4	3	4	13	22	5	2
January 13	157	265	27	38	3	7	102	188	29	43	4	2	3	8	4	9	1	2
January 14	135	229	82	84	4	8	135	207	37	55	4	6	6	5	7	7	5	6
January 15	102	245	56	87	4	6	72	201	20	40	2	6	4	28	6	7	3	6
January 16	131	272	81	93	5	5	127	184	18	38	5	8	18	8	6	9	7	4
January 17	34	88	40	82	2	6	57	120	21	35	4	7	9	30	4	7	2	7
January 18	14	192	24	16	1	4	17	215	10	36	5	6	4	7	4	7	1	6
January 19	15	76	14	33	1	4	29	128	15	34	1	4	2	14	3	7	4	7
January 20	23	223	65	173	1	9	31	315	20	42	1	5	2	8	4	11	3	7
January 21	20	98	23	80	16	4	32	248	16	255	30	10	2	4	3	10	0	2
January 22	13	84	11	106	2	8	11	250	10	30	1	7	1	4	1	4	1	3
January 23	8	37	25	28	1	2	23	122	10	29	2	2	0	3	5	6	1	3
January 24	38	81	26	57	1	6	32	145	11	22	2	4	3	4	2	6	1	3
January 25	27	58	22	62	1	4	36	98	13	28	3	4	0	3	1	6	2	3
January 26	23	84	42	70	1	3	42	114	14	21	1	2	2	4	4	8	2	5
January 27	17	38	13	27	1	2	24	57	10	13	2	2	3	3	5	5	2	3
Average	74.9	176.5	35.9	63.1	4.0	6.0	55.8	173.0	28.7	56.5	5.0	5.6	4.7	7.3	4.8	10.1	3.1	4.7

[1] Two Coleman (C) and 2 Dietz (D) lanterns were used. Conducted on two trees when panicles were almost fully developed. Height—6 meters. One (D) on one side of tree and a (C) on other side. Places exchanged every day.

TABLE 15.—*Showing the average daily response of leafhoppers, tip-borers and other insects to Dietz and Coleman lights and to weather factors*—Continued

Date 1934	Mean hourly temperature (6 P. M.—5 A. M.)	Mean hourly humidity (6 P. M.—5 A. M.)	General daily remark on weather conditions	Phases of the moon
	°C.	*Per cent*		
January 9	22.5	86.9	Fair	
January 10	24.6	90.3	Cloudy	
January 11	24.4	90.5	Rain for 20 minutes before 9 P. M.	
January 12	23.3	96.0	Heavy rain in the morning; squally and drizzly nights	
January 13	24.6	92.6	Shower from 1:30 to 3:30 P. M.	
January 14	23.3	88.6	Clear	New moon.
January 15	22.5	94.5	Rain for one-half hour before 3 P. M.; shower at night	
January 16	23.7	85.5	Fair	
January 17	22.7	85.5	Fair	
January 18	23.3	87.5	Fair	
January 19	23.5	84.5	Fair	
January 20	23.6	88.0	Fair	
January 21			Rain for one-half hour in the afternoon	First quarter.
January 22	20.2	79.5	Fair	
January 23	20.5	75.9	Fair	
January 24	19.55	76.1	Fair	
January 25	21.16	70.7	Fair	
January 26	20.93	74.8	Fair	
January 27	19.6	87.7	Fair	
Average				

times as much *I. clypealis* as the Dietz lantern. *I. clypealis* was somewhat indifferent in its response to the lights used, because, despite its great preponderance in the trees where the traps were set, more *I. niveosparsus* than this species were always caught (Tables 15 and 16). It is largely possible that a certain colored light is necessary for greater attraction of *I. clypealis*. As shown in Tables 15 and 16 the tip-borer adults were not also highly positively phototropic. Various species of other insects falling under different groups were caught but of these the lepidopterous group were best represented not only in number of species but also in many cases in number of individuals of each species. From the viewpoint of control on commercial basis, this is economically beneficial because the caterpillars of many of those lepidopterous insects are destructive to the mango inflorescences and newly-set fruits.

The response of insects to artificial lights is influenced by certain environmental factors, among which, temperature, humidity, wind velocity, rainfall, and lunar phases may be considered important. It is difficult to correlate any of these factors with the nightly collections of insects in Tables 15 and 16 because they all acted at one and the same time and also because they showed wide range of variations which were not uniform for all nights. The existing temperature, humidity and air movement may be favorable for the attraction of insects, but if the night is bright, not many insects will be caught. From the data presented in Tables 15 and 16 it is shown that high attraction of leafhoppers took place during the period of from January 9 to January 16, except on January 12 when the mean hourly humidity was 96.0 per cent and the night rather drizzly or squally. During the period of high attraction the nights were dark, the humidity was rather high, and the mean hourly temperature was between 22.5°C. and almost 25°C. It was not possible, however, to determine from these data how much of the attraction was due to dark night, to humidity and to temperature.

The daily capture from January 17 to January 27 (Tables 15 and 16) were much less than those from January 9 to January 16. Lower mean hourly temperature and humidity and bright nights acting together were responsible for this low attraction of leafhoppres.

More studies on light trapping of leafhoppers and other insects attacking mango, especially, with the use of colored lights are necessary in order to ascertain further if their control by this

TABLE 16.—*Showing the average daily attraction of leafhoppers, tip-borers and other insects to Dietz lights, and to daily weather factors*

Date (1934)	*I. niveosparsus*	*I. clypealis*	Tip-borer moth	Other moths	Flies and mosquitoes	Hymenoptera	Orthoptera	Coleoptera	Other hoppers (Homoptera)	Mean hourly temperature (6 P. M.—5 A. M.)	Mean hourly humidity (6 P. M.—5 A. M.)	General daily remark on weather conditions	Phases of the moon
										°C.	*Per cent*		
January 9	128	22	11	56	34	6	7	----	----	22.5	86.9	Fair	----
January 10	275	24	9	77	36	10	9	11	8	24.6	90.3	Cloudy	----
January 11	235	59	6	123	145	8	13	8	8	24.4	90.5	Rain for 20 minutes before 9. P. M.	----
January 12	64	45	5	85	88	4	3	14	4	23.3	96.0	Heavy rain in the morning; squally and drizzly night.	----
January 13	119	57	4	126	24	5	3	5	4	24.6	92.6	Shower from 1.30 to 3.30 P. M.	----
January 14	112	47	4	104	26	5	5	7	4	23.3	88.6	Fair	New moon.
January 15	82	52	5	100	25	3	6	6	3	22.5	94.5	Rain for one-half hour before 3 P. M., shower at night.	----
January 16	79	54	4	89	25	5	8	5	7	23.7	85.5	Fair	----
January 17	55	32	4	47	17	4	2	4	3	22.7	85.5	Fair	----
January 18	54	25	4	63	17	4	2	4	4	23.3	87.5	Fair	----
January 19	39	26	2	48	23	5	2	5	3	23.5	84.5	Fair	----
January 20	40	65	2	61	21	5	4	5	3	23.6	88.0	Fair	----
January 21	18	44	6	42	23	3	2	4	3	----	----	Rain for one-half hour in the afternoon.	First quarter.
January 22	11	19	1	23	14	1	2	4	2	20.2	79.5	Fair	----
January 23	13	34	1	27	13	2	1	3	4	20.5	75.9	Fair	----
January 24	35	31	2	32	12	2	2	1	2	19.55	76.1	Fair	----
January 25	34	39	1	33	17	2	2	2	2	21.16	70.7	Fair	----
January 26	29	40	2	31	12	2	1	2	3	20.93	74.8	Fair	----
January 27	21	22	1	34	13	2	2	4	2	19.6	87.7	Fair	----

method is possible. The daily capture shown in Tables 15 and 16, being generally low, does not give sufficient assurance that the use of either Dietz or Coleman lanterns for the control of leafhoppers and tip-borer will be beneficial. Their use may, however, help minimize the volume of leafhopper and tip-borer infestation if started when the inflorescence buds are bursting; and for the purpose of catching other mango insects injurious to the inflorescences and newly-set fruits it should be continued until the flowers have shed their petals. Light trapping with the use of Dietz or Coleman lamp is an expensive operation and it cannot be advocated at present for the control of mango insects.

SUMMARY AND CONCLUSIONS

The combined attack of leafhoppers (*Idiocerus niveosparsus* Leth. and *Idiocerus clypealis* Leth.) and tip-borer (*Chlumetia transversa* Wlk.) on mango inflorescence in the Philippine has occasioned enormous losses of the crop during the last five or six years. These pests are widespread in all of the principal mango-growing regions in the Philippines.

The tip-borer pest, which is caused by the larva of *Chlumetia transversa,* appears, to be most active only when the mango trees are in leaf or flower flush. It was observed, however, to be more destructive to the off-season flowers than to the normal season flowers. The attack of this pest on the leaf shoots produced during the rainy months is sometimes severe.

Chlumetia transversa is a grayish black moth, 8 to 10 millimeters long having a wing spread of about 16 to 18 millimeters. The forewings are crossed by wavy black lines at basal, subbasal, medial, and discal parts, and a row of linear black spots at the margin. The male and female are alike in body characters, except that the male has a black crest on from the second to the fourth abdominal segment. The eggs are creamy white, ellipsoidal, 1.2 millimeters long and 0.74 millimeter thick. They are laid singly on the flower stem and young shoots and hatch in about 4.1 days on the average. The newly-hatched larva feeds for a certain period on the soft tender tissues before it bores into the panicle or shoot. The larva is inside the tender terminal growth during the greater part of its life and comes out of it only when it attacks a fresh growth. The pupal stage is spent in the soil. From the data obtained the life cycle of

this insect from the egg to the adult stage is 26.5 days on the average.

The application of 0.5 per cent lead arsenate at intervals of 3 or 4 days beginning when the panicles are about 2 to 6 centimeters long was found to aid greatly in reducing the ravages of the tip-borer pest. This control was, however, found useless in increasing the crop unless the leafhoppers which are always found associated with the tip-borer pest are also satisfactorily controlled.

The results of seven series of spraying experiments to control the leafhoppers with soap solution of 0.5 and 0.4 per cent concentrations are discussed.

While laundry soaps are effective in killing the leafhopper nymphs, not all solutions of soaps from different factories are safe to apply to the mango flowers owing to their variability in composition. The solution of the soap obtained from the Philippine Manufacturing Company in Manila was found less injurious to the flowers while that of the soap obtained from the factory in Pasay, Rizal, was highly injurious. Even with the use of soap, least injurious to the flowers, it cannot be assured that there would be profit because of the presence of many factors which may upset the yield. Heavy fruit-shedding and the severe attack of other mango insects, such as caterpillars and beetles on flowers and fruits and maggots on fruits are among those factors. In spraying for profit, it is, therefore, very necessary to bring as many of those factors under control as possible.

In extreme cases of leafhopper infestation spraying with 0.4 or 0.5 per cent soapsuds at 3 days interval has been observed to be of little or no value in preventing the damage of the crop since between applications of the spray, the inflorescences are often seriously injured by the nymphs from new hatchings. This, therefore, necessitates more frequent spraying which may be objectionable because it is tedious, expensive, and likely to impair fertilization of the flowers.

Thorough drenching of the inflorescences is an important requisite in spraying for leafhopper nymphs with soap solution. A profusely-flowered tree in Novaliches Mango Plantation required from 350 to 600 liters of the soapsuds discharged from a hand pump in from 3 to 4 hours to thoroughly wet its inflo-

rescenses during each spraying. Even with the use of such large amount of spray, still some more nymphs may be observed unharmed, especially on parts of the tree where blossoming is thick.

For reasons indicated above, spraying for leafhoppers on mango inflorescence with soap solution should be undertaken with great caution. Owing to the sensitiveness of the mango flowers, especially while open, stress should be placed upon the importance of using the proper kind of soap that will cause the least injury to the flowers. Before using the soap it should be tested first on a number of healthy inflorescences with open flowers. If it does not cause injury to the flowers after 3 to 5 days it might be safe to use it for large-scale spraying for leafhoppers.

The other methods of controlling the leafhoppers on mango inflorescence should be tried. It is highly probable that better results will be obtained with the use of certain dusts deleterious to these insects if applied during the abundance of the adults when the trees are not in flower. The natural enemies of the leafhoppers should also be studied and the possibility of using them for their control should be investigated.

The phototropic response of leafhoppers, tip-borers and other mango insects was studied. Although the leafhoppers and tip-borers exhibit positive phototropism, the attraction of these pests to either an ordinary light from Dietz lantern or a powerful light from Coleman lamp is not sufficiently high to warrant the use of any of these lamps as light traps for the control of these pests. Their use will, however, aid greatly in minimizing the infestation if set during the flowering period. Dark nights and calm weather with mean humidity of around 90.0 per cent seem to favor large attraction of these insects.

LITERATURE CITED

1. BALLARD, E. Mango hopper control experiments. *Agric. Journ.* India, Calcutta. *10:* (1915) 395–398.
2. BHASIN, H. D. Annual report of the Entomologist to Government, Punjab, Lyallpur for the year ending 30th June 1925. (1926) Rept. Dept. Agric. Punjab, Part I (1924–1925): 20–27. Lahore. *Cited in Rev. App. Ent. 14:* 423.
3. DISTANT, W. L. The Fauna of British India, including Ceylon and Burma, Rhynchota *4* (1908): 185–187.
4. FLETCHER, T. BAINBRIGGE. Annotated list of Indian Crop-pests. *Agr. Res. Institute, Pusa, Bull. 100* (1921): 1–246.

5. HAMPSON, G. F. Catalogue of the Lepidoptera Phalænae in the British Museum *11* (1912): 68.
6. HARTLESS, A. C. Mango crops and some factors influencing them. *Agric. Journ.*. India, Pusa, *9* (1914): 141–159.
7. HUSAIN, M. A. and H. S. PRUTHI. Preliminary note on the winter-spraying against mango hopper (*Idiocerus* spp.) vernacular name, Tela Rept. Proc. 4th Ent. Meeting, Pusa, Feb. 1921. Calcutta 1921: 148–152.
8. HUSAIN, M. A. Report of the Imperial Entomologist. Sci. *Repts. Agric. Res. Inst. Pusa,* 1925–1926 (1926): 70–82.
9. KANNAN, K. K. Report of the Entomologist. Admin. Rept. Agric. Dept. Mysore, 1922–1923, Part I (1924): 4–5, Part II: 16–20. Cited in *Rev. App. Ent. 12:* 424.
10. KANNAN, K. K. Report of the Entomologist. Admin. Rept. Agric. Dept. Mysore, 1923–1924, Part II (1925): 10–12. Cited in *Rev. App. Ent. 13:* 643.
11. KANNAN, K. K. 1930. The annual administration report of work done in the Entomological Section, during 1928–1929. *Ann. Rept. Agric. Dept.* Mysore, 1928–1929: 29–33. *Cited in* Rev. App. Ent. *19.*
12. LEEFMANS, S. Instituut voor Plantensiekten. Zoologisch Laboratorium. Jaarb. Dept. Landb. Ned.-Indie, 1927: 47–54. Weltevreden. Cited in *Rev. App. Ent. 16* (1928): 627.
13. LETHIERRY, M. L. Definitions of three new Homoptera. *Journ. of the Asiatic Soc. of Bengal. 58* (1889): 252–253.
14. MADAN MOHAN LAL. Report of the Assistant Professor of Entomology. Rept. Dept. Agric. Punjab, Year ended 30th June 1917. Lahore. Cited in *Rev. App. Ent. 8* (1917): 109.
15. MERINO, G. 1929. Plant Pest Control Division. *28th Ann. Rept. Phil.* Bur. Agric. 1928: 67–78.
16. OTANES, F. Q. Insects: Their relation to man and their control. *Phil. Agric. Rev.* 18 (1925): 373–410.
17. PALO, M. A. Anthracnose and important insect pests of mango in the Philippines, with a report on blossom-spraying experiments. *Phil. Journ. Sci. 48* (1932): 209–235.
18. PERRIERE, C. New chalcidoid egg-parasites from South Asia. *Bull. Ent. Res. 22* (1931): 279–295. Cited in *Rev. App. Ent. 19:* 358.
19. RAMACHANDRA RAO, Y. The mango hopper problem in South India. *Agric. Journ.* India, Calcutta. *25* (1930): 17–25.
20. SCHUMACHER, F. Der gegenwartige stand unserer Kenntnis von der Homopteren Fauna der Insel Formosa, Mitt. Zool. Mus. Berlin, *7* (1915): 73–134. Cited in *Rev. App. Ent. 8:* 85–86.
21. SERRANO, F. B. and M. A. PALO. Blossom blight of mangos in the Philippines. *Phil. Journ. Sci., 50* (1933): 211–277.
22. SUBRAMANIA IYER, T. V. Notes on the more important insect pests of crops in the Mysore State. III Diptera. IV Rhynchota. Journ. Mysore Agric. & Exptl. Union, Bangalore. *4* (1922): 18–24. 3 fig. Cited in *Rev. App. Ent. 10:* 389–390.

23. SUBRAMANIAM, T. V. The insecticidal properties of indigenous vegetable fish poisons. *Journ. Mysore Agric. Exptl.* Union, Bangalore. *13* (1932): 57–60. 2 figs.

24. VAN HALL, C. J. J. Ziecten en Plagen der Cultuurgewasen in Nederlandsch-Indie in 1923. Meded. Inst. Plantenziecten, No. 64 (1924): 1–47. Weltevreden.

25. WALKER, F. List of the specimens of the Lepidopterous insects in the collection of the British Museum, *27* (1863): 114.

26. WESTER, P. J. Mango pests in Cavite and Rizal. *Phil. Agric. Rev.* *4* (1911): 312–314.

27. WESTER, P. J. Mango-hopper control. *Phil. Agric. Rev. 19* (1916): 159–160.

28. WESTER, P. J. The mango. *Phil. Bur. Agric. Bull. 18* (1920): 5–70.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Inflorescences of Pico mango showing the attack of the tip-borer pest. Note the presence of the larva of *Chlumetia transversa* in the cavity in each inflorescence; about ½ natural size.

2. A twig of Carabao mango showing the tip-borer infested shoots. Note the shriveled condition of the attacked shoots; about "X" ⅓. (The illustrations in this plate are Bureau of Science photographs obtained from Mr. F. B. Serrano.)

PLATE 2

FIG. 1. A portion of the flower stem showing an egg deposited by the female moth, *Chlumetia transversa;* about × 3.

2. *Chlumetia transversa*, newly-hatched larva; about × 3.
3. *Chlumetia transversa*, mature larva; about × 3.
4. *Chlumetia transversa*, pupa; about × 3.
5. *Chlumetia transversa*, male moth; about × 3.
6. *Chlumetia transversa*, female moth; about × 3.
7. *Chelonus* sp., a hymenopterous parasite of the larva of *Chlumetia transversa;* about × 3.

PLATE 3

FIG. 1. A healthy carabao mango inflorescence; about × ½.

2. A carabao mango inflorescence badly attacked by leaf-hopper nymphs. Note the presence of numerous leaf-hopper nymphs on the peduncle and laterals of the inflorescence; about × ½.

PLATE 4

FIG. 1. A Carabao tree in full bloom with right half sprayed with lead arsenate for tip-borer followed by soap spraying of leafhopper nymphs, leaving the left half unsprayed as check. Note the difference between the sprayed and unsprayed halves. The sprayed flowers looked fresh and healthy while the unsprayed inflorescences appeared black due to the severe leafhopper infestation; × 1/80. (Photographed after the fourth spraying.)

2. The same tree as in fig. 1, with the check inflorescences completely destroyed by the leaf-hopper nymphs and with about two-thirds of the sprayed inflorescences destroyed by the young adult leafhoppers which had migrated from the unspread half; about 1/80. (Photographed a week after the fifth spraying.)

PLATE 5

FIG. 1. A carabao tree showing the complete ruin of both the unsprayed flowers (left half) and the inflorescences sprayed with lead ar-

senate for tip-borer followed by soap spraying for leafhopper nymphs (right half). The destruction of the sprayed half was also due to the attack of young leafhopper adults which had migrated from the check flowers; about × 1/80.

FIG. 2. A carabao tree with entire crown sprayed with lead arsenate for tip-borer followed by soap spraying for leafhopper nymphs. Note that about one-half of the inflorescences had already been destroyed by the young leafhopper adults which had migrated from the unsprayed trees; about × 1/80.

PLATE 6

FIG. 1. A carabao tree used in the fifth series of soap spraying experiments showing moderate number of mature fruits; about × 1/60.

2. One of the two check trees used in the fifth series. On close observation of the picture, some of the peduncles with laterals already detached may be seen; about ×1/70.

PLATE 7

FIG. 1. A carabao mango showing the early stage of the attack of *Phytorus lineolatus*. Note the presence of the beetle on the eaten-up portions of the rind of the fruit; about × 1½.

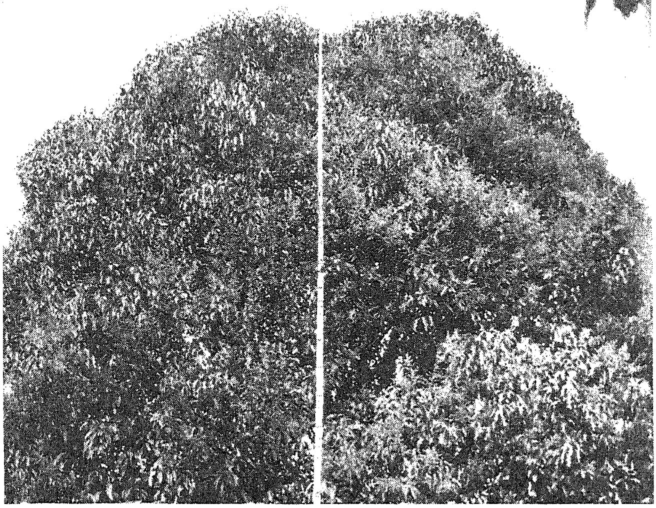
2. Carabao mango fruits badly attacked by *Phytorus lineolatus*. Note the amount of eaten-up rind and flesh of the fruits and the sign of rotting along the edges of eaten-up areas; slightly less than natural size.

1

2

PLATE 1.

PLATE 3.



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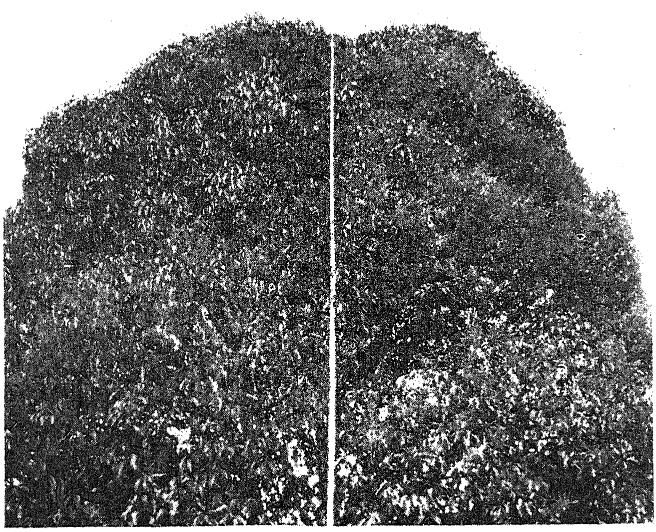

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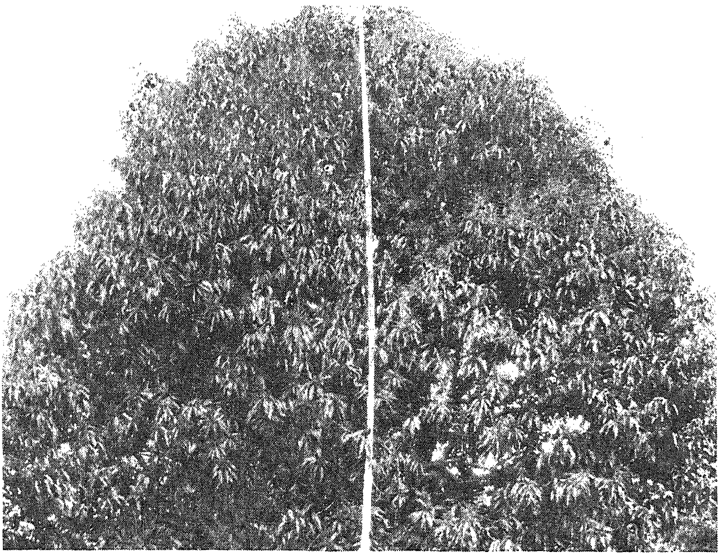
PLATE 4.



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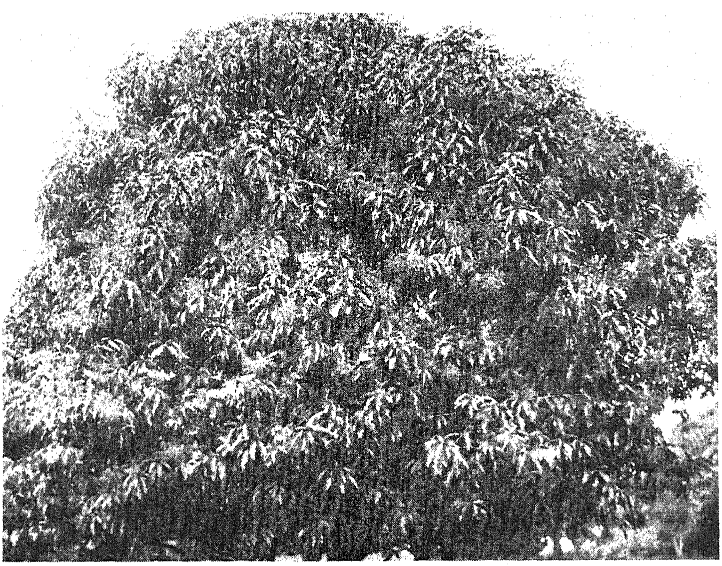

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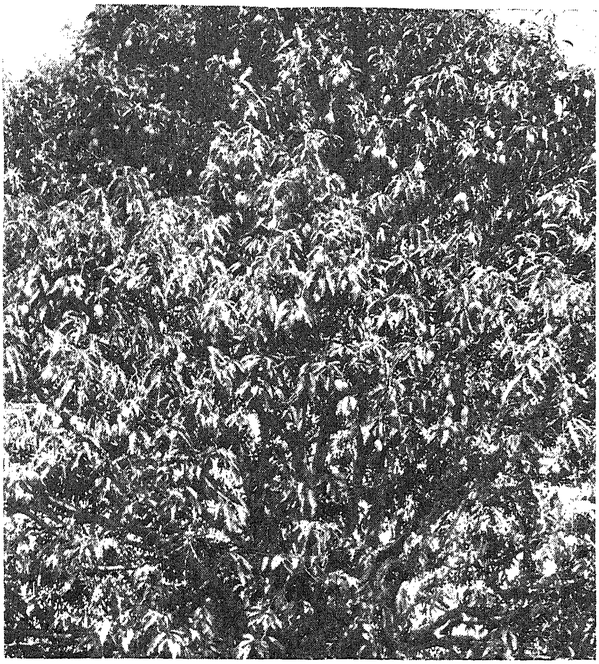
PLATE 5.



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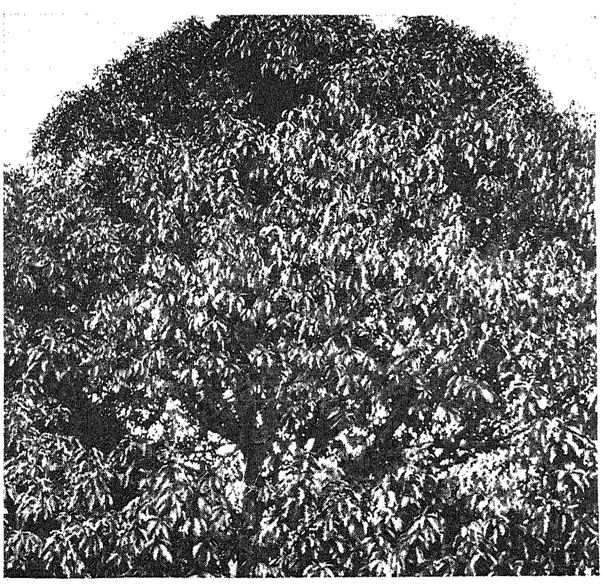

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PLATE 6.

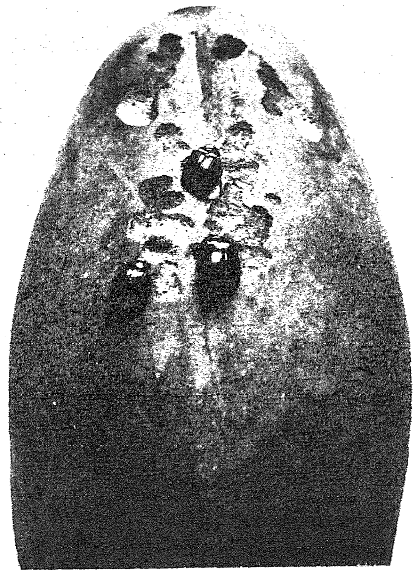

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PLATE 7.

PRELIMINARY STUDY ON THE FIRE-HOLDING CAPACITY OF PHILIPPINE-GROWN CIGAR LEAF WRAPPERS

By SALVADOR B. OLIVEROS and C. G. RAMOS
Of the Agricultural Chemistry Section
Bureau of Plant Industry

ONE PLATE AND TWO TEXT FIGURES

One of the most important qualities of a tobacco leaf especially when intended for use as wrapper is its capacity to hold fire. A method of determining this quality, which has long been in use, consists of burning the leaf by means of a lighted cigar or a slow burning match and noting the number of seconds it continues to glow. This method is not very reliable because of the fact that even with a single leaf the variation is so great that little reliance can be placed upon the results except in a general way. The study here reported is an attempt to apply a more exact method of determining the fire-holding capacity of wrappers, based essentially on the area of leaf burnt. This method was reported by Garner (1907).

MATERIALS AND METHODS

The essential part of the apparatus is the form used to hold the leaf. This is cylindrical, of well seasoned wood $5\frac{3}{8}$ inches in length, $\frac{3}{4}$ inch in diameter at one end, and tapering slightly at the other end. Through the larger end of the cylinder, a $\frac{3}{8}$ inch hole was bored to a depth of $4\frac{3}{4}$ inches and the shell thus formed was separated into six equal segments by sawing to the same depth of $4\frac{3}{4}$ inches. A portion $1\frac{1}{2}$ inches from the smaller end was reduced in diameter so as to fit evenly with the sides of a glass receiver described below, the shoulder thus formed corresponding in depth to the thickness of the wall of the glass receiver. A plug for the larger end of the form was made of such diameter that when inserted in place, the form would assume its original diameter. The receiver for the form was made by drawing out one end of a short piece of glass tubing, the dimensions of which conformed to the dimensions of the wooden form. The glass tubing used had an internal diameter of 14

mm. and an external diameter of 18 mm. The smaller end of the receiver was fitted with a soft cork by means of which it was connected with the other portion of the apparatus.

The wrappers which were to be used in the experiment were first sprayed with water to make them workable. Each wrapper was cut into a form similar to the right-hand or left-hand wrappers usually used in the manufacture of cigars. The plug was inserted in the hole in the bigger end of the wood form. A wrapper was rolled around the form by first pasting the overlapping portion. At the end of the process, the tobacco was pasted on to the glass receiver. Several leaves were rolled in the same manner and then allowed to dry in the air overnight. They were then oven-dried at 40°C. for 2 hours, after which they

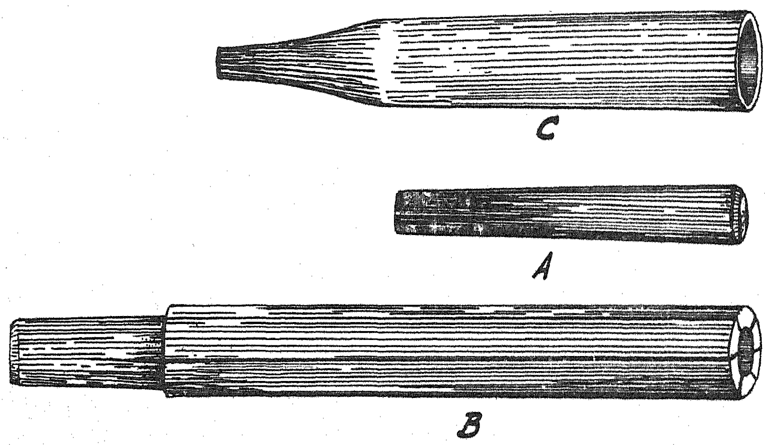


FIG. 1. Form for rolling the wrapper: *C*—glass adapter; *B*—cylinder; A—plug for *B*.

were ready for the test. The plug in the form was removed, causing the end of the form to collapse, and by careful manipulation the wooden form was removed, leaving the wrapper attached to one end of the glass adapter in the same form as it would have on a cigar. The wrapper was cut evenly, 9 cm. away from the glass. The glass adapter with the formed wrapper attached was fitted by means of its cork to the rest of the apparatus. The pump was so regulated that the discharge was 2 liters per minute, producing a slow suction through the whole apparatus. The wrapper was lighted by means of a flat flame. With the aid of a certified stop watch, the actual duration of time from the moment of lighting to the instant the glow was extinguished was taken.

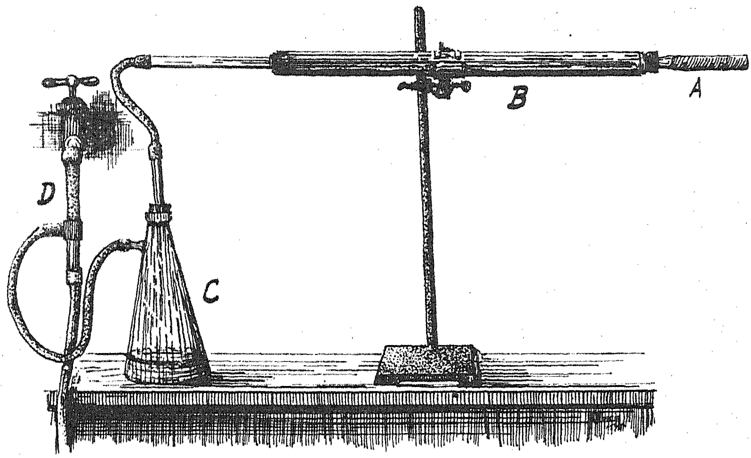


FIG. 2. Apparatus for testing the fire-holding capacity of wrappers: *A*—Wrapper in place; *B*—Smoke tube; *C*—Suction flask; *D*—Suction pump.

RESULTS AND DISCUSSION OF RESULTS

The results of these studies are compiled in Table 1. The samples used were hybrids selected by Mr. M. E. Gutierrez of the Breau of Plant Industry. From the wrapper leaves selected as many wrapper forms were made as to give the number of tests shown on the table. As stated above, the wrappers were cut exactly 9 cm. from the mouth of the glass adapter. As also stated, the duration of burn indicates the number of minutes registered by a stop watch from the time of lighting to the time the glow was extinguished. The area consumed per minute was taken as the quotient of the length consumed divided by the duration of burn. Since all the wrapper forms were made identical, the circumference of each corresponding section of any two wrappers should be equal. If this circumference be taken as unity, then this value multiplied by the quotient of the length consumed divided by the duration of burn will represent identical functions of the area, which may be considered equivalent to the area consumed per minute. The probable errors of the length consumed and of the duration of burn were computed by the standard formula. The probable error of the area consumed per minute was determined by considering the probable errors of the maximum and minimum values of the length consumed and the duration of burn.

Table 1 shows that of the 25 samples treated, Sample 5 burned the least with only 2.62 ± 1.46 cm. consumed. The duration of

burn of this sample was also shortest, being 1.86 ± 0.61 minutes. Sample 10 burned completely, with a duration of burn of 2.90 ± 0.13 minutes. The length consumed in Sample 1 was 8.97 ± 0.02, that in Sample 20 was 8.96 ± 0.03, and in Sample 21, 8.93 ± 0.04. Sample 5, with a length of 2.62 ± 1.46 cm. consumed, Sample 12 with 2.89 ± 0.55 cm., and Sample 6 at 3.37 ± 0.83 cm., burned least.

The longest duration of burn was in sample 1, which was 5.42 ± 0.23 minutes; in Sample 9, with 5.37 ± 0.44; and in

TABLE 1.—*Tests with the fire holding capacity of some Philippine wrappers*

Sample	Number of tests	Length of rolled wrapper	Length consumed	Duration of burn	Area consumed per minute
		cm.	*cm.*	*Min.*	*1×cm.*
1	8	9.0	8.97±0.02	5.42±0.23	1.65±0.14
2	8	9.0	8.64±0.25	2.44±0.11	3.54±0.23
3	7	9.0	8.21±0.19	2.91±0.09	2.82±0.09
4	9	9.0	8.15±0.55	4.40±0.48	1.85±0.37
5	5	9.0	2.62±1.46	1.86±0.61	1.41±1.85
6	9	9.0	3.37±0.83	2.21±0.40	1.52±0.80
7	8	9.0	6.61±0.71	4.25±0.27	1.56±0.28
8	8	9.0	8.70±0.08	3.87±0.14	2.25±0.10
9	8	9.0	8.23±0.51	5.37±0.44	1.67±0.26
10	8	9.0	9.00	2.90±0.13	3.10±0.15
11	8	9.0	7.08±0.44	3.47±0.21	2.04±0.26
12	9	9.0	2.89±0.55	3.04±0.38	0.95±0.34
13	7	9.0	5.81±0.90	3.01±0.20	1.93±0.46
14	7	9.0	4.48+0.99	3.23±0.66	1.39±0.74
15	6	9.0	7.71±0.94	5.07±0.67	1.52±0.45
16	8	9.0	6.47±0.50	4.04±0.34	1.60±0.28
17	9	9.0	8.64±0.15	3.35±0.22	2.58±0.22
18	9	9.0	8.21±0.50	2.82±0.13	2.91±0.33
19	8	9.0	7.55±0.70	4.07±0.26	1.86±0.30
20	7	9.0	8.96±0.03	2.36±0.10	3.80±0.18
21	6	9.0	8.93±0.04	2.64±0.08	3.38±0.10
22	7	9.0	8.04±0.58	2.81±0.15	2.86±0.38
23	9	9.0	7.93±0.54	3.03±0.19	2.62±0.30
24	7	9.0	7.21±0.33	2.85±0.13	2.53±0.25
25	9	9.0	8.07±0.55	3.59±0.14	2.25±0.25

Sample 15, with 5.07 ± 0.67 minutes. Sample 5 burned the shortest time, 1.86 ±0.61 minutes.

Sample 20 with 3.80 ± 0.18 square units consumed per minute, Sample 2 with 3.54 ± 0.23, Sample 21 with 3.38 ± 0.10 and Sample 10 with 3.10 ± 0.15 showed the greatest area consumed per minute. The area consumed per minute in Sample 12 was 0.95 ± 0.34; in Sample 14, 1.39 ± 0.74; and in Sample 7, 1.56 ± 0.28.

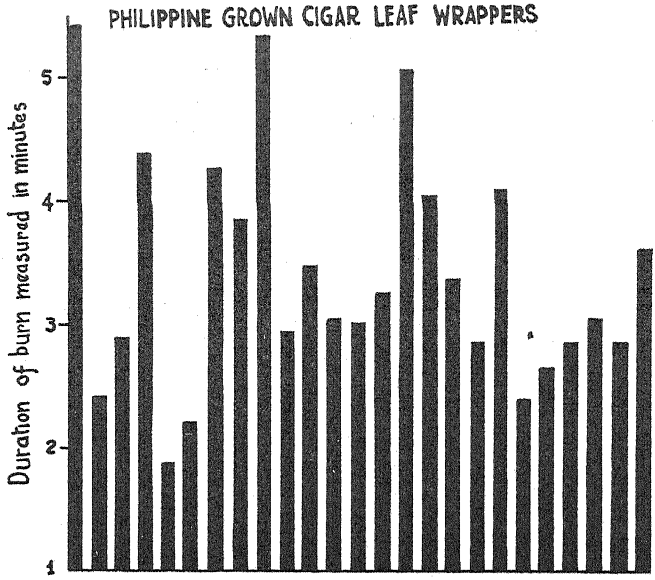
As stated above, the test reported in this paper takes consideration more of the area consumed per minute than of any other factor. Table 1 gives the area consumed per minute for the different samples, the value of each of them may be compared with one another. The least area consumed per minute was 0.95 ± 0.34, which apparently indicates a very slow burning wrapper. The observed cause for this slow burning was the mode of burning of the wrapper. A glow appeared like a streamer, going in a circular way around the wrapper form and giving the appearance that at each moment only one point in the wrapper was burning. This method of burning accounted for the uneveness of the burn and would not be desirable for a wrapper.

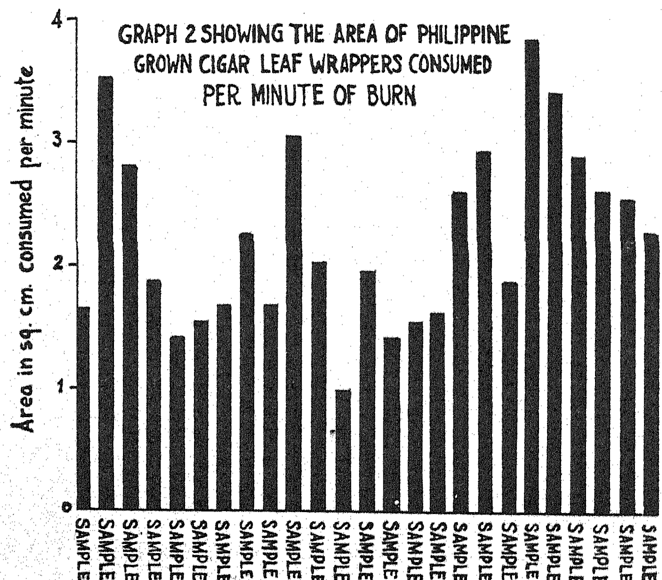
For a wrapper that was fast burning there is Sample 20 in which the area consumed per minute was 3.80 ± 0.18 with a relatively even burn.

Graphs 1 and 2 show the results graphically. From these it is apparent that Samples 12, 14, 5, 6, 16, 1, 7 and 9 are slow burning, while Samples 20, 2, 21 and 10 are fast burning. It may also be seen in these graphs that the area consumed per minute appears to be a better indication of the fire-holding capacity.

The above tests also indicate that the method of testing cigar wrappers reported in this study may be made use of, especially when comparative tests are conducted on wrappers subjected to the same conditions of selection and treatment. In the data presented for example, the probable error shows the evenness of reaction to the tests. Considering for example only the area consumed per minute, the probable error is, for many samples, not more than 0.30 which, in these cases, is below $\frac{1}{5}$ of the values. A high probable error would of course indicate undesirability of the wrapper tested. Basing on this consideration, we might state that on the whole, the test presented in this paper may be applied usefully to testing wrappers, provided the ordinary precautions as regards sampling and uniformity of treatment are followed. It is recognized that the value of wrapper also depends to a great extent upon the filler and binder used with it. However, it is essential that the quality of a wrapper should also be tested and that a method of accurate presentation of its inherent qualities be devised. The work presented in this paper was an attempt to accomplish this purpose.

GRAPH 1 SHOWING THE DURATION OF THE BURN OF PHILIPPINE GROWN CIGAR LEAF WRAPPERS





SUMMARY

1. Twenty-five samples of Philippine-grown cigar wrappers were tested for fire-holding capacity.

2. The duration of burn was longest in Samples 1, 9, and 15. This was due to a peculiar mode of burning wherein a single glowing point burned in a circular way around the wrapper like a streamer. The duration of burn was shortest in Sample 5.

3. Sample 5 was consumed the least. Sample 10 burned completely. Samples 1, 20, and 21 were almost totally consumed.

4. Using the area consumed per minute as criterion, Samples 12, 14, and 5 were slow burning wrappers.

REFERENCES

ADRIANO, F. T., C. G. RAMOS and R. A. ISIDRO. The chemical composition of cigarettes and cigarette tobacco leaves of the aromatic and non-aromatric types. Phil. Journ. of Agr. 4 (1933): 87–97.

GARNER, W. W. Methods of testing the burning quality of cigar tobacco. U. S. Dept. of Agr. Bull. 100 (1906): 31–40.

ILLUSTRATIONS

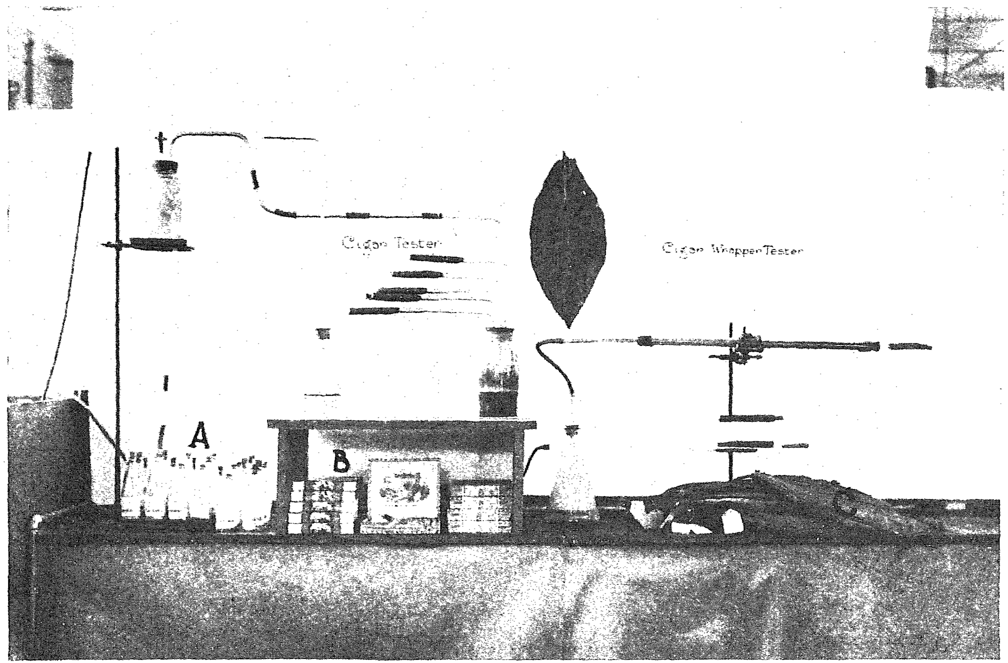


PLATE 1.

A NEW THRIPS ON COTTON [1]

By Dudley Moulton [2]

The present paper records the finding of a new thrips which is a pest on cotton and other plants in the vicinity of Manila. The collections were made by Mr. F. Q. Otanes and were forwarded to me for identification by Mr. Jose S. Camus, Director of Plant Industry of the Department of Agriculture and Commerce. The new genus to which this species belongs is named *Bussothrips* from the Greek word "bussos" which means cotton or linen. I take pleasure in acknowledging the courtesy of Mr. Camus for forwarding these specimens to me for identification.

Genus BUSSOTHRIPS Moulton, 1935

(Family THRIPIDAE Uzel, Subfamily HELIOTHRIPINAE Karny)

Reticulation of body distinct only on first seven abdominal segments. Head wider than long; eyes large occupying fully half the length of the head, ocelli approximate. Maxillary palpus with two segments. Antenna with eight segments, three four and six long and slender, three clearly constricted at both ends; style thripoid rather than heliothripoid in shade. Interocellar spines long, prominent. Prothorax wider than long; without marking; spines on anterior margin and a pair at each posterior angle long, prominent. Hind coxae approximate. Wings long, slender, only normally enlarged at base; with pointed tips; fore wing with ring vein complete, fore longitudinal vein united with costa at basal third, hind vein distinct; costal spines and fringe well developed; fore vein with six scattered spines in basal half, three in distal half, hind vein with three scattered spines in distal half.

Male with a part of thorns seated on long tubercles, on ninth abdominal segment and with two upwardly curved rods at tip.

BUSSOTHRIPS CLARATIBIA Moulton, new species.

Female holotype.—Color head and thorax yellowish brown with orange pigment, abdomen blackish brown. Antennal segments

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[1] Received for publication, October 1, 1935.

[2] Former Director of the State of California Department of Agriculture.

one and two concolorus with head, three, four, basal halves of five and six mostly clear yellow, but with a shading of brown, distal halves of five, six light brown as are also seven and eight. Legs with all femora dark brown joints lighter, all tibiae and tarsi yellow except fore tibiae which are shaded in basal half. Fore wings clear in first, middle and last fifths and with two distinct dark cross bands in second and fourths fifth; hind wings clear but with a dark median line which fades before the end. (In lighter specimens the abdomen is brown but darker toward the tip.)

Total body length 1.5 mm. Head length .13 mm., width .176 mm.; prothorax length .12 mm., width .22 mm., Antennal segments: length (width) II, 33 (26); III, 73 (16); IV, 56 (18); V, 50 (16); VI, 70 (16); VII, 16; VIII, 23; total 326 microns. Length of spines: interocellar 53, on anterior margin of pronotum 66, on anterior angle 26, pair at posterior angles 70–80 microns; on ninth abdominal segment 140, on tenth 126 microns.

Head clearly wider than long, with transverse anastimosing lines behind eyes; interocellar spines placed within the ocellar triangle; a series of six smaller spines circling posterior margin of each eye; mouthcone extending two-thirds over prosternum, maxillary palpus with two segments. Antenna more than two and one-half times longer than head; forked sense cones on segments three and four; segment three, 4.5 times longer than greatest width, segment six almost equally as long; segments three and four constricted long and necklike at distal ends.

Prothorax without markings except two or three incomplete lines near posterior margin at sides; spines on anterior angles short, those on anterior margin about two and one-half times longer; pair at posterior angles longest; inward from these, only two extremely small spines along posterior margin. Character of wings as given in generic description. Legs slender, without armature. Comb on eighth abdominal segment complete.

Male allotype.—Colored as in female, somewhat smaller; armed at tip as given in generic description.

Type material.—Female holotype, male allotype, twenty-one female and two male paratypes taken on cotton October 29, 1934, by F. Q. Otanes and Jose S. Camus. Moulton No. 5301. Types in author's collection.

Type locality.—Singalong, Manila, Philippine Islands.

This genus and species belongs in the Family *Thripidae* Uzel but its placement in a subfamily is more difficult. The structure

of the wings excludes it from the subfamily *Thripinae* Karny, although its other body characters resemble those of a *Taeniothrips* Serville. The lack of microscopic pubescence on the abdomen and strongly developed spines on the thorax would seem to exclude it from the subfamily *Sericothripinae* Karny. I am therefore placing it in the subfamily *Heliothripinae* Karny, and near the genus *Hercothrips* Hood, from which it is easily distinguished by the shape of the antennal segments, lack of reticulation on head and thorax and the strongly developed postoculars and other spines an prothorax.

296570——8

A PRELIMINARY STUDY ON THE BURNING QUALITY OF CIGARS PREPARED WITH NATIVE AND IMPORTED WRAPPERS

By SALVADOR B. OLIVEROS, C. G. RAMOS and D. B. PAGUIRIGAN
Of the Bureau of Plant Industry

ONE TEXT FIGURE

INTRODUCTION

The annual average of Philippine exports of leaf tobacco for a period of 5 years, from 1928 to 1932, amounted to 6½ million pesos, while the annual average imports of the same commodity for the same period was nearly one million pesos. It is interesting to note that while the exported leaf tobacco commanded a price of ₱0.31 per kilo, the imported brand had a price of ₱2.67 per kilo. The explanation for this contrast is not hard to surmise. Although no itemized data on Philippine trade in tobacco is obtainable, it is obvious that as regards leaf tobacco trade, the Philippines can only export cigar fillers, since this type of tobacco is locally produced in abundance. Cigar fillers are the lowest-priced tobacco leaf. On the other hand, it is also obvious that the Philippines must import only aromatic cigarette filler and cigar wrapper, the costliest type of tobacco leaf in the market, inasmuch as, especially in the case of the former, the country does not yet produce sufficient quantities to meet the local demand.

A considerable portion of Philippine leaf tobacco imports consists of aromatic cigarette tobacco because of the increasing local manufacture of American style cigarettes. According to the local office of the American Trade Commissioner, the average yearly importation of aromatic cigarette tobacco into the Philippines for the years 1930, 1931 and 1932 amounted to ₱178,455 and of leaf tobacco, ₱782,963, thus leaving a probable average annual importation of cigar wrapper leaf tobacco amounting to about ₱600,000.

While Philippine imports of cigar wrappers have considerably decreased, from former values of about ₱2,000,000 to about ₱1,000,000 annual averages, as shown in Table 1, it is quite ob-

vious and economically sound that the Philippines should strive to produce more cigar wrappers not only to be self-sufficient in this commodity but also to be able to supply part of the cigar wrapper imports of the United States of which a portion coming from the Dutch East Indies was valued from ₱6,000,000 to ₱39,000,000 during the period from 1929 to 1932.

In the production of the types of tobacco to meet both the local and foreign markets, constant and continuous effort is being made by the Government and by a few courageous individuals and commercial firms. Success so far attained has partly been due to adoption of many foreign methods and partly through research to lower the cost of production, a factor that has served as a stumbling block to widespread culture. Although Paguirigan (1927), says that the best native grown wrappers are

TABLE 1.—*Cigar and tobacco leaf wrappers trade of the Philippines from 1929 to 1932*

Year	Cigars		Tobacco leaf wrappers			
	Exported		Exported		Imported	
	Quantity Number	Value Pesos	Quantity Kilos	Value Pesos	Quantity Kilos	Value Pesos
1928	220,884,441	9,530,279	20,217,486	6,059,265	370,158	1,838,609
1929	188,333,006	7,649,297	27,578,991	8,784,870	229,321	1,180,893
1930	178,560,744	7,090,446	20,770,616	7,451,758	186,916	851,467
1931	183,873,661	6,790,674	22,653,099	7,002,991	358,217	682,089
1932	182,574,853	6,462,436	21,620,470	5,644,466	848,354	815,334

comparable, in general appearance, to the imported product, and that there are possibly just as many brands and shapes of high-priced cigars wrapped with the native product as with the imported, still there is plenty of room for improving the locally-grown cigar leaf wrappers.

The never-ending experiments in breeding and selection in this country to produce the types of tobacco that could compete with those in the open market require methods of testing to show even slight differences in the particular quality or qualities desired. When a cigar tobacco is judged for its different qualities due regard must be given to each of the 3 components—the filler, the binder, and the wrapper—each of which has certain characteristics. The filler must have a fine flavor, aroma and a good burn. The wrapper, among its many properties, must possess a desirable color, shape and size; must be free from

any objectionable taste; must have sufficient elasticity to be worked conveniently; must have fine veins; and most important of all, must have a good burn. The last mentioned quality is of great importance for any tobacco crop. There have been several instances when crops of tobacco which have practically all the qualities to be desired were found useless because they would not burn. The burning quality of a cigar is not so simple as it appears to be. There are several elements which enter to make a good burn; namely, the capacity for holding fire, the evenness of the burn, coaling, "puckering"or the shrinking of the leaves immediately before the burning area, the firmness of the burn, and the rate of burning.

In the present work an attempt was made to convert all these qualities into linear measurements. Among the different qualities of a good burn, those that are easiest to detect are the evenness of the burn and the character of the ash. Garner (1907) found in his experiments that due consideration should be given to the proper balancing of the components of the cigar; that is, a heavy filler should be wrapped with a comparatively heavy wrapper, while a light-bodied filler requires a light bodied wrapper. With regards to the character of the ash, he is of the opinion that the influence of the wrapper and the binder is shown most strongly by the character of the ash, and that the binder materially influences the ash of the wrapper in this respect.

OBJECT OF THE PRESENT WORK

In the local trade in cigar leaf wrappers, the dealers in native wrappers and the importers of foreign wrappers claim, without any attempt to support such claim with scientific data, that their respective wrappers are better than the others. Without prejudice against any dealer's product, the present work has for its object the comparison of the burning qualities of native with imported cigar leaf wrappers with respect to the different elements that make a good burn.

MATERIALS AND METHODS

The cigars used were specially prepared for this experiment. The cigars having the same brand were made as closely uniform to each other as possible. The filler and binder used for each brand were the same in all cases. The cigars were specially ordered from a single cigar maker. For each brand having the same filler and binder five different wrappers were used; name-

ly, Isabela-grown and La Union-grown Vizcaya, which is a native wrapper; imported Sumatra, and Puerto Rico-grown and Georgia-grown Havanensis wrappers. The cigars were smoked by an appropriate apparatus in order to eliminate any personal equation.

The apparatus shown in Figure 1 may be briefly described as follows: The "mouths" or pipes *a*, *b*, *c*, *d* and *e*, were of exactly equal lengths. Five pipes were used in order to subject the five differently wrapped cigars under the same conditions of smoking.

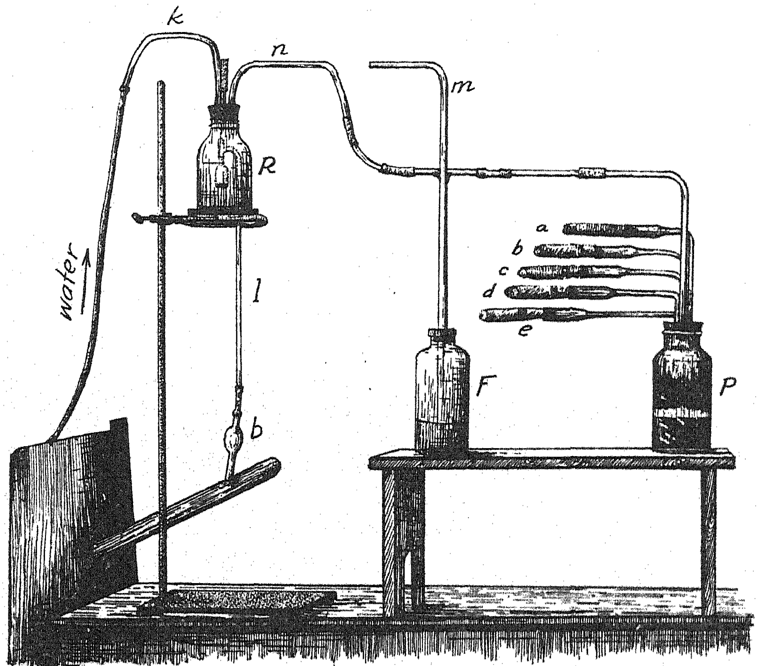

FIG. 1. Mechanical cigar smoker.

Between the flask *P* holding the mouth-end of the pipes and the aspirator *R* was another flask *F* with a two hole-rubber stopper. Through one of the holes was inserted a check valve consisting of a T-tube the lower arm of which reached beneath the surface of the water in the flask *F*. This arrangement was to prevent a backward pressure while the aspirator was filling. Through the other hole and flush with the inner surface of the stopper of flask *F* was passed another glass tubing *m* for carrying out the obnoxious fumes. The aspirator *R* consisted of a mason jar provided with a two-hole rubber stopper. Through one of

the holes was inserted a tube *n*, leading to the flask containing the pipes and through the other hole, another tube *k* supplying water from the faucet. A hole was made at the base of the mason jar and the long arm *l* of the siphon was inserted.

The long arm *l* was 58.6 cm. with an inner diameter of 9 mm. The discharge end of this long arm of the siphon was provided with a bulb *b* for helping break the flow of water at the moment the aspirator was emptied. The short arm of the siphon was 11 cm. long with an inner diameter of 3 mm. for 6 cm. of its length, the rest being tapered to the size of the connecting glass tubing. The operation of the aspirator was timed with a stop-watch so that it would fill in 30 seconds and empty in 10 seconds. The actual time of suction was therefore 10 seconds for every 40 seconds.

The close end of the cigar was cut in the ordinary way of cutting cigars for smoking. For each brand 5 cigars with different wrapers were tightly placed in the pipes. There were ten tests with each brand, so that each of the 5 cigars of the same wrapper occupied each of the five pipes two times.

In the case of cigars in which the open end consisted of the entire cross-sectional area of the cigar, lighting was done by applying a low flame on the open end during a suction period. When the aspirator began to empty again the flame was applied on the cigar in the next pipe and so on until all the cigars were lighted. The time was taken at the instance of the first lighting. After the cigars have burned to a reasonable length the color of the ash was taken by comparing its color with a suitable color standard (Ridgway, 1912). The lengths of the points in the burnt cigar farthest and nearest the mouth were measured as soon as the ash first fell, and also at the termination of the smoking period. The average length of the cigar when the ash fell was subtracted from the initial length of the cigar and the difference recorded as firmness of ash. The average at the termination of smoking period was subtracted from the initial length, and the difference was taken as length consumed. The minimum and maximum width of coaling were also measured; the average of the two was termed coaling. The shrinking of the wrappers immediately before the burning area was noted. The other observations made were the number of lightings to start the burning of the cigar and the duration of burn when a cigar stopped burning before the time limit.

RESULTS AND DISCUSSION OF RESULTS

The wrappers used in the study were Vizcaya wrapper grown in Isabela and termed Isabela; Vizcaya wrapper grown in La Union and termed La Union; Havanensis wrapper from Georgia, termed Georgia, Havanensis wrapper from Puerto Rico, termed Puerto Rico, and imported Sumatra wrapper.

The observations and measurements obtained from mechanically smoking the 700 cigars used in these studies were too voluminous, and it was deemed wise not to include the complete experimental data in this report. Table 2, giving sample sheets from the laboratory notebooks, however, shows how the experimental data were gathered. The measurements indicated were taken by means of a pair of dividers and an accurately graduated millimeter scale. In Table 2 is given the length of cigar at the beginning of the test; the maximum, minimum and average lengths of the cigar after smoking; the length consumed, which was taken as the difference between the length of the cigar at the beginning of the test and the average length after smoking; and the length of the cigar when the ash first fell. This last measurement was subtracted from the initial length of the cigar to get the length of the first ash, which was taken as the firmness of ash. The difference between the maximum and minimum lengths of the cigar after smoking is given as the evenness of burn. The time limit for all smoking was 30 minutes, and cigars ceasing to burn before the time limit were duly recorded. The number of lightings indicates how many times a lighted match-stick had to be applied to the open end of the cigar before the said cigar commenced to burn. The color of the ash was determined by comparison with standard color tables, and at the end of a set of experiments the ash of the differently wrapped cigars were compared one with another to find which ash was darkest and which was whitest. The whitest ash was indicated as 1 and the darkest as 5.

Four of the measureable qualities obtained in Table 2 were subjected to statistical treatment. Table 3 shows the averages, with probable errors, of ten samples for the evenness of burn, firmness of ash, coaling and length consumed, for each wrapper for each brand. The formula used for the probable error of the average was $P.E. = \pm 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$ where *P. E.* is the probable error, Σv^2 is the sum of the squares of the differences of the actual values from the average, and n is the number of

TABLE 2.—*Sample sheets from laboratory notebook on smoking tests*

Set No.	Wrapper	Length of cigar: At beginning of test	Length of cigar: After smoking: Maximum	Length of cigar: After smoking: Minimum	Length of cigar: After smoking: Average	Length of cigar: Consumed	Length of cigar: When ash first fell	Time of smoking	Length of first ash	Evenness of burn	Number of lightings	Coaling: Maximum	Coaling: Minimum	Coaling: Average	Color of ash: Actual	Color of ash: Rank in test 1st=1; 5th=5	"Puckering"
		cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*min.*	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*			
1	LU-1	13.9	9.8	8.8	9.3	4.6	8.8	30	5.1	1.0	1	0.3	0.1	0.2	Pallid purplish gray	5	Very slight.
	S-2	13.9	3.3	2.6	3.0	10.9	5.1	30	8.8	0.7	1	0.2	0.1	0.2	Pale dull gray	1	Slight.
	G-3	13.9	6.1	5.6	6.9	8.0	7.4	30	6.5	0.5	2	0.3	0.1	0.2	Pallid purplish gray	2	Very slight.
	PR-4	13.9	6.4	5.8	6.1	7.8	7.6	30	6.3	0.6	1	0.3	0.1	0.2	Pale neutral gray	4	Slight.
	I-5	13.9	5.6	5.2	5.4	8.5	7.8	30	6.1	0.4	1	0.2	0.1	0.2	Pallid neutral gray	3	Very slight.
3	PR-1	13.9	4.2	3.9	4.1	9.8	7.8	30	6.1	0.3	1	0.2	0.1	0.2	Pallid neutral gray	5	Very slight.
	I-2	13.9	4.8	4.1	4.5	9.4	6.6	30	7.3	0.6	1	0.4	0.1	0.3	French gray	3	Slight.
	LU-3	13.9	5.7	5.3	5.5	8.4	7.4	30	6.5	0.3	1	0.2	0.1	0.2	Pallid neutral gray	4	Slight.
	S-4	13.9	6.3	5.8	6.1	7.8	8.2	30	5.7	0.5	1	0.3	0.1	0.2	Pale dull gray	1	Slight.
	G-5	13.9	6.3	6.1	6.2	7.5	8.2	30	5.7	0.2	1	0.3	0.2	0.3	Pallid purplish gray	2	Slight.
9	G-1	13.9	4.0	3.6	3.8	10.1	7.4	30	6.3	0.4	1	0.3	0.1	0.2	Pallid purplish gray	2	Very slight.
	PR-2	13.9	4.5	3.9	4.2	9.7	7.8	30	6.0	0.6	1	0.3	0.1	0.2	Pale neutral gray	4	Very slight.
	I-3	13.9	5.1	4.5	4.8	9.1	8.2	30	5.7	0.6	1	0.2	0.1	0.2	Light dull gray	5	Slight.
	LU-4	13.9	8.0	7.5	7.8	6.1	7.5	30	6.4	0.5	1	0.3	0.1	0.2	Pale dull gray	3	Slight.
	S-5	13.9	4.8	3.4	4.1	9.8	7.6	30	6.3	1.4	1	0.4	0.1	0.3	Light dull gray	1	Slight.

TABLE 3.—*Measurement of four smoking qualities of cigars*

Brand and wrapper	Evenness of burn	Firmness of ash	Coaling	Length of cigar consumed in 30 min.
Brevas:				
Georgia	0.89±0.14	6.13±0.26	2.15±0.22	7.57±0.38
Isabela	0.83±0.10	5.80±0.26	2.29±0.17	5.92±0.36
La Union	0.72±0.09	6.06±0.12	1.97±0.23	6.47±0.21
Porto Rico	1.13±0.15	6.20±0.50	2.33±0.18	6.78±0.66
Sumatra	0.63±0.07	5.90±0.44	1.83±0.11	6.75±0.50
Cazadores:				
Georgia	0.77±0.03	5.62±0.20	2.22±0.17	7.44±0.37
Isabela	0.77±0.12	5.64±0.15	1.78±0.12	6.73±0.49
La Union	0.62±0.06	5.49±0.21	1.90±0.11	6.70±0.36
Porto Rico	0.61±0.06	5.05±0.22	2.38±0.23	5.83±0.41
Sumatra	0.85±0.12	5.98±0.34	2.31±0.22	7.92±0.38
Conchas:				
Georgia	0.62±0.06	6.62±0.25	1.92±0.11	6.78±0.32
Isabela	0.46±0.06	5.65±0.24	1.61±0.07	6.54±0.43
La Union	0.52±0.05	5.50±0.13	1.87±0.08	5.61±0.18
Porto Rico	0.73±0.07	6.20±0.16	1.88±0.04	6.33±0.19
Sumatra	0.60±0.06	5.71±0.28	1.82±0.09	6.01±0.34
Exquisitos:				
Georgia	0.58±0.09	6.45±0.17	1.80±0.11	6.70±0.19
Isabela	0.60±0.04	6.33±0.15	1.70±0.05	6.77±0.16
La Union	0.55±0.07	6.28±0.13	1.94±0.13	7.21±0.27
Porto Rico	0.59±0.04	6.47±0.17	1.65±0.08	8.30±0.40
Sumatra	0.74±0.14	6.76±0.24	2.16±0.23	7.17±0.23
Favoritos de Carrion:				
Georgia	0.74±0.05	6.02±0.20	2.24±0.11	7.84±0.30
Isabela	0.65±0.07	6.90±0.24	2.30±0.19	8.01±0.32
La Union	0.80±0.12	6.50±0.25	1.92±0.12	8.36±0.19
Porto Rico	0.47±0.06	5.74±0.42	1.97±0.18	8.27±0.34
Sumatra	0.40±0.04	6.16±0.22	1.87±0.06	8.03±0.30
High life:				
Georgia	0.85±0.07	6.00±0.20	1.99±0.14	6.11±0.35
Isabela	0.47±0.03	6.40±0.16	1.66±0.07	6.85±0.19
La Union	0.59±0.03	6.20±0.29	1.60±0.09	6.40±0.27
Porto Rico	0.71±0.08	6.43±0.18	2.00±0.13	6.96±0.38
Sumatra	0.62±0.08	5.93±0.32	1.88±0.10	6.52±0.33
Imperiales:				
Georgia	0.52±0.06	6.05±0.12	2.57±0.19	8.16±0.26
Isabela	0.66±0.06	6.47±0.15	2.07±0.18	8.30±0.18
La Union	0.65±0.11	6.12±0.17	2.16±0.09	7.96±0.42
Porto Rico	0.50±0.05	6.17±0.07	2.09±0.11	8.01±0.31
Sumatra	0.61±0.06	6.21±0.21	2.07±0.09	8.30±0.30
Londres:				
Georgia	0.57±0.05	5.28±0.21	2.00±0.10	7.44±0.35
Isabela	0.41±0.02	5.06±0.34	1.72±0.11	6.40±0.32
La Union	0.66±0.11	5.64±0.40	2.07±0.13	7.35±0.27
Porto Rico	0.37±0.06	5.19±0.20	1.90±0.12	5.79±0.09
Sumatra	0.62±0.11	5.20±0.16	1.87±0.10	7.12±0.24
Media Regalia:				
Georgia	0.62±0.09	5.81±0.27	2.90±0.19	7.52±0.35
Isabela	0.60±0.03	5.85±0.20	1.73±0.07	6.18±0.25
La Union	0.74±0.08	6.20±0.23	2.10±0.10	6.80±0.20
Porto Rico	0.65±0.06	5.91±0.21	1.99±0.05	6.63±0.28
Sumatra	0.60±0.07	5.55±0.11	1.99±0.09	6.60±0.20

TABLE 3.—*Measurement of four smoking qualities of cigars*—Continued.

Brand and wrapper	Evenness of burns	Firmness of ash	Coaling	Length of cigar consumed in 30 min.
Monterrey:				
Georgia	1.09 ±0.13	4.79 ±0.30	2.88 ±0.18	5.53 ±0.64
Isabela	1.12 ±0.15	5.45 ±0.53	2.62 ±0.16	5.07 ±0.47
La Union	1.34 ±0.11	4.75 ±0.32	2.68 ±0.23	6.43 ±0.55
Porto Rico	0.75 ±0.12	4.99 ±0.28	2.32 ±0.15	6.86 ±0.59
Sumatra	0.93 ±0.10	5.53 ±0.30	2.22 ±0.15	6.29 ±0.45
Panetelas Imperiales:				
Georgia	0.89 ±0.18	5.02 ±0.19	2.61 ±0.19	7.12 ±0.49
Isabela	0.35 ±0.02	4.77 ±0.39	2.10 ±0.11	7.80 ±0.45
La Union	0.59 ±0.06	4.64 ±0.23	2.32 ±0.10	6.57 ±0.55
Porto Rico	0.47 ±0.07	5.43 ±0.30	2.00 ±0.08	8.14 ±0.37
Sumatra	0.44 ±0.06	4.64 ±0.24	2.00 ±0.14	8.34 ±0.64
Perfectos:				
Georgia	0.64 ±0.08	5.45 ±0.19	1.89 ±0.10	5.48 ±0.23
Isabela	0.59 ±0.08	5.48 ±0.28	1.90 ±0.20	5.69 ±0.39
La Union	0.62 ±0.06	5.67 ±0.18	1.78 ±0.09	5.40 ±0.21
Porto Rico	1.12 ±0.28	5.92 ±0.21	2.09 ±0.12	5.91 ±0.24
Sumatra	0.72 ±0.11	5.93 ±0.32	2.42 ±0.08	5.64 ±0.32
Regalia Imperial:				
Georgia	0.90 ±0.14	5.44 ±0.46	2.51 ±0.20	5.97 ±0.56
Isabela	0.54 ±0.03	5.84 ±0.27	2.16 ±0.15	6.79 ±0.35
La Union	0.82 ±0.08	5.85 ±0.44	2.32 ±0.20	6.48 ±0.55
Porto Rico	1.36 ±0.41	5.72 ±0.36	2.28 ±0.20	5.75 ±0.41
Sumatra	1.18 ±0.13	5.76 ±0.44	2.48 ±0.16	5.87 ±0.56
Regentes:				
Georgia	0.75 ±0.08	5.72 ±0.30	2.47 ±0.17	6.37 ±0.48
Isabela	0.74 ±0.09	5.99 ±0.29	1.97 ±0.08	6.84 ±0.38
La Union	0.56 ±0.05	5.60 ±0.24	2.26 ±0.19	6.42 ±0.31
Porto Rico	0.57 ±0.11	5.99 ±0.20	1.96 ±0.09	6.46 ±0.44
Sumatra	0.76 ±0.10	6.34 ±0.30	2.30 ±0.20	7.04 ±0.38

samples which in this case was 10. The wrappers in every brand were compared one with another, that is, for example, for the brand Brevas these comparisons were made: Georgia *vs.* Isabela; Georgia *vs.* La Union; Georgia *vs.* Puerto Rico; Georgia *vs.* Sumatra; Isabela *vs.* La Union; Isabela *vs.* Puerto Rico; Isabela *vs.* Sumatra; La Union *vs.* Puerto Rico; La Union *vs.* Sumatra; and Puerto Rico vs. Sumatra. The probable error of the difference between any two averages was computed using the formula: $P.E._{(A\text{-}B.)} = \sqrt{(P.E.)^2_A + (P.E.)^2_B}$ that is the probable error of the difference between two averages is the square root of the sum of the squares of their probable errors. When the difference was 3 or more than 3 times the value of its probable error, the difference was significant. The results of

such comparisons, when the differences between any two measurements were significant, are given in Table 4. It will be noted that the differences that were significant were very few in comparison with the total number of measurements taken. Thus in evenness of burn only 10 out of 700 measurements or of 70 averages, gave significant differences; in firmness of ash only 2, in coaling only 7 and in length consumed only 8. The averages that gave significant differences were only 4.82 per cent of the total number of camparisons. It may then be inferred that in a general way, there was no difference at all between the wrappers as far as the 4 measurable qualities—evenness of burn, firmness of ash, coaling and length consumed—were concerned.

In Table 4 under evenness of burn, in the brand Favoritos de Carrion, Georgia, compared with Puerto Rico, gave a difference of 0.27 ± 0.08. As shown, Georgia had the higher measurement and Puerto Rico the lower value. In evenness of burn the higher measurement indicates inferiority, since the evenness of burn was taken as the difference between the maximum and minimum lengths of the cigar after burning, whereby a cigar burning very evenly would show no difference in measurements. The same table shows that the firmness of ash, in the brand Conchas, Georgia *vs.* La Union, showed difference of 1.12 ± 0.29, meaning that Georgia had a longer ash than La Union and therefore was better in this respect. Under length consumed, in the brand Brevas, Georgia gave a bigger measurement than Isabela by 1.65 ± 0.52, and since for the time limit, it was considered that the longer the portion of cigar consumed the better, Georgia showed a superiority over Isabela in this respect.

The number of instances that any wrapper showed superiority over or inferiority to another wrapper in Table 4 was recorded in Table 5. Under evenness, of burn, for example, in Table 5, for the wrapper Georgia, there was no instance in which it showed superiority over any other wrapper; but in four instances it was inferior to some other wrapper. By subtracting the instances of inferiority from the instances of superiority, a balance was obtained, either a positive or negative number, depending on how the wrapper behaved. In the example of Georgia the balance was —4. For the same quality the wrapper Isabela was superior to some other wrapper in 4 instances but inferior in 1 giving a balance of +3; La Union was superior in

TABLE 4.—*Differences in measurements of four smoking qualities of cigars*

Brand	Wrapper Higher numerical value *vs.* Lower numerical value	Difference
1. *Evenness of burn: Lower numerical value indicating superiority:*		
Favoritos de Carrion	Georgia *vs.* Porto Rico	0.27±0.08
	Georgia *vs.* Sumatra	0.34±0.07
	Isabela *vs.* Sumatra	0.25±0.08
	La Union *vs.* Sumatra	0.40±0.13
High Life	Georgia *vs.* Isabela	0.38±0.08
	Georgia *vs.* La Union	0.26±0.08
Monterrey	La Union *vs.* Porto Rico	0.59±0.17
Panetelas Imperiales	La Union *vs.* Isabela	0.24±0.07
Regalia Imperial	La Union *vs.* Isabela	0.28±0.09
	Sumatra *vs.* Isabela	0.64±0.13
2. *Firmness of ash: Higher numerical value indicating superiority:*		
Conchas	Georgia *vs.* La Union	1.12±0.29
	Porto Rico *vs.* La Union	0.70±0.20
3. *Coaling: Lower numerical value indicating superiority:*		
Conchas	Porto Rico *vs.* Isabela	0.27±0.08
Media Regalia	Georgia *vs.* Isabela	1.17±0.20
	Georgia *vs.* La Union	0.80±0.21
	Georgia *vs.* Porto Rico	0.91±0.19
	Georgia *vs.* Sumatra	0.91±0.21
Perfectos	Sumatra *vs.* Georgia	0.53±0.13
	Sumatra *vs.* La Union	0.64±0.12
4. *Length consumed: Higher numerical value indicating superiority:*		
Brevas	Georgia *vs.* Isabela	1.65±0.52
Cazadores	Sumatra *vs.* Porto Rico	2.09±0.56
Exquisitos	Porto Rico *vs.* Georgia	1.60±0.45
	Porto Rico *vs.* Isabela	1.53±0.43
Londres	Georgia *vs.* Porto Rico	1.65±0.36
	La Union *vs.* Porto Rico	1.56±0.27
	Sumatra *vs.* Porto Rico	1.33±0.26
Media Regalia	Georgia *vs.* Isabela	1.34±0.43

1 instance and inferior in 4, giving a balance of —3; Puerto Rico was superior in 2 instances and did not record any instance of inferiority, giving a balance of +2; and Sumatra was superior in 3 instances and inferior in one, giving a balance of +2. To give points arbitrarily to each wrapper, the lowest score indicated by the lowest arithmetical value was given no point. In the example taken Georgia scoring —4 was given zero, La Union scoring —3 was given 1 point, Puerto Rico and Sumatra both scoring +2 were given 6 points each, and Isabela scoring +3 was given 7 points. The score and the points awarded were on the same scale, only moved forward so that no negative value would be shown. The firmness of ash, coaling, and length

TABLE 5.—*Scores of wrappers for all brands for four smoking qualities*

Wrapper	Evenness of burn: Instances Superior	Evenness of burn: Instances Inferior	Evenness of burn: Instances Balance	Evenness of burn: Points awarded	Firmness of ash: Instances Superior	Firmness of ash: Instances Inferior	Firmness of ash: Instances Balance	Firmness of ash: Points awarded
Georgia	0	4	−4	0	1	0	+1	3
Isabela	4	1	+3	7	0	0	0	2
La Union	1	4	−3	1	0	2	−2	0
Porto Rico	2	0	+2	6	1	0	+1	3
Sumatra	3	1	+2	6	0	0	0	2

Wrapper	Coaling: Instances Superior	Coaling: Instances Inferior	Coaling: Instances Balance	Coaling: Points awarded	Length consumed: Instances Superior	Length consumed: Instances Inferior	Length consumed: Instances Balance	Length consumed: Points awarded
Georgia	1	4	−3	0	3	1	+2	5
Isabela	2	0	+2	5	0	3	−3	0
La Union	2	0	+2	5	1	0	+1	4
Porto Rico	1	1	0	3	2	4	−2	1
Sumatra	1	2	−1	2	2	0	+2	5

consumed were treated likewise. This method of awarding points gave equal emphasis to the 4 qualities scored.

The color of ash is another quality very often used to judge cigars. Table 6 shows the score of each wrapper under each brand for the color of ash. In Table 2 for each set of tests the color of the ash of each cigar was compared with those of the others. The whitest ash was given a grade of 1 and the darkest ash was given a grade of 5. Table 6 shows the sum of the scores on color of ash. The wrapper showing the whitest ash with the most frequency for each brand naturally obtained the smallest total. Basing upon these totals the rank in the brand was noted. The smallest total was given 1 and the highest total was given 5, showing that the wrappers with the smallest total was the best wrapper as far as the color of the ash was concerned. Table 6 also gives the grand total for all brands and likewise the rank in the whole test showing that as far as the color of ash was concerned the rank was as follows: Sumatra, Isabela, Georgia, Puerto Rico and La Union. Awarding points in the same manner as described above, Georgia obtained 2 points; Isabela, 3; La Union, 0; Puerto Rico, 1; and Sumatra, 4.

TABLE 6.—*Color of ash*

Brand	Wrapper	Total points	Rank in brand
Brevas	Georgia	37	3
	Isabela	35	2
	La Union	28	1
	Porto Rico	28	1
	Sumatra	28	1
Cazadores	Georgia	21	2
	Isabela	35	3
	La Union	40	5
	Porto Rico	38	4
	Sumatra	16	1
Conchas	Georgia	24	2
	Isabela	25	3
	La Union	30	4
	Porto Rico	45	5
	Sumatra	21	1
Exquisitos	Georgia	19	1
	Isabela	29	3
	La Union	46	5
	Porto Rico	32	4
	Sumatra	28	2
Favoritos de Carrion	Georgia	34	4
	Isabela	29	3
	La Union	41	5
	Porto Rico	24	2
	Sumatra	22	1
High Life	Georgia	35	3
	Isabela	32	2
	La Union	38	4
	Porto Rico	35	3
	Sumatra	10	1
Imperiales	Georgia	23	2
	Isabela	34	4
	La Union	45	5
	Porto Rico	33	3
	Sumatra	15	1
Londres	Georgia	24	2
	Isabela	33	3
	La Union	41	5
	Porto Rico	36	4
	Sumatra	15	1
Media Regalia	Georgia	45	5
	Isabela	17	2
	La Union	38	4
	Porto Rico	35	3
	Sumatra	14	1
Monterrey	Georgia	25	1
	Isabela	27	2
	La Union	37	4
	Porto Rico	34	3
	Sumatra	25	1
Panetelas Imperial	Georgia	37	4
	Isabela	26	1
	La Union	34	3
	Porto Rico	27	2
	Sumatra	26	1

TABLE 6.—*Color of ash*—Continued.

Brand	Wrapper	Total points	Rank in brand
Perfectos	Georgia	26	2
	Isabela	22	1
	La Union	45	4
	Porto Rico	26	2
	Sumatra	28	3
Regalia Imperial	Georgia	26	2
	Isabela	25	1
	La Union	41	5
	Porto Rico	30	4
	Sumatra	27	3
Regentes	Georgia	32	4
	Isabela	23	1
	La Union	39	5
	Porto Rico	31	3
	Sumatra	25	2
For all brands			Rank in test
	Georgia	408	3
	Isabela	392	2
	La Union	543	5
	Porto Rico	454	4
	Sumatra	300	1

The number of lightings, that is, the number of times a lighted matchstick had to be applied to the free end of a cigar at the commencement of the smoking is another indication of the smoking quality of such a cigar. Actual counts in the test showed that the number of second re-lightings for each wrapper out of the 140 samples were; Georgia 5, Isabela 5, La Union 5, Puerto Rico 7 and Sumatra 6. As far as this quality was concerned therefore the wrappers were practically the same.

Another smoking quality looked for in cigars is invariably the continuity of burn; that is, for a given length of smoking, a smoker desires that he lights a cigar only once and that the cigar burns continuously to the stub. The mechanical smoker used in this test was particularly satisfactory for making observations in this respect, since most of the conditions that would be variable in a smoker's mouth were equalized or made constant. Actual count showed that the number of cigars that ceased to burn before the time limit, was by wrappers, as follows: Georgia 2, Isabela 4, La Union 2, Puerto Rico 2, Sumatra 3. Since there were 140 cigars smoked the differences shown above are negligibly small.

The sum of the points awarded each wrapper in Table 5 are as follows:

Georgia	8
Isabela	14
La Union	10
Puerto Rico	13
Sumatra	15

The differences between wrappers were not very marked, especially if it is remembered that 700 samples were tested.

It will also be remembered that the tests were made on the assumption that for each brand, filler and binder were as uniform as possible. Since the manipulations in the manufacture of these cigars preclude such a uniformity, differences in the behavior of the cigars under satisfactorily constant conditions of smoking must be considerable in order that correct judgment of the wrappers can be made. No such marked differences were found in these tests.

SUMMARY

1. Five wrappers were ordered used in making fourteen brands of cigars in such a manner that filler and binder for each brand were as uniform as possible for the brand. The wrappers used were: La Union-grown Vizcaya; Isabela-grown Vizcaya; Georgia-grown Havanensis; Puerto Rico-grown Havanensis and Sumatra-grown Sumatra. Ten cigars in each wrapper having the same brand were mechanically smoked in ten sets by a 5-mouthed smoking apparatus such that each mouth smoked a differently wrapped cigar in each set of tests. Linear measurements as indices of evenness of burn, firmness of ash, coaling and length consumed, were taken. Observations were made as to the number of lightings to start the burn, "puckering", cessation of burn prior to the time limit set, and color of ash, both actual and relative. The measurements gathered were subjected to statistical treatment to find significant differences.

2. Of 700 comparisons of average measurements for each quality, there were 10 significant differences in the evenness of burn, 2 in firmness of ash, 7 in coaling and 8 in the length consumed. It is apparent, therefore, that there was hardly any difference between any two differently wrapped cigars.

3. Sumatra wrapped cigars gave the greatest frequency, and the whitest ash; followed in turn by cigars wrapped in Isabela, Georgia, Puerto Rico and La Union wrappers.

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4. Provided that the limitations necessarily attending the tests described are kept in mind, the method is believed satisfactory and of utility.

REFERENCES

1. GARNER, W. W. Methods of testing the burning quality of cigar tobacco. U. S. Dept. of Agr. Bull. 100 (1907): 31–40 Pl. 3–4 Fig. 2–4.
2. GARNER, W. W. The relation of the composition of the leaf to the burning qualities of tobacco. U. S. Dept. of Agr. Bull. 105 (1907): 1–27.
3. GARNER, W. W. The relation of nicotine to the quality of tobacco. U. S. Dept. of Agr. Bull. 141 (1909): 5–16.
4. LAVA, V. G., and S. B. ETORMA. Comparative analysis of American and Philippine cigarettes. The Phil. Agr. 10: 17 (1928): 565–573.
5. LEAÑO, P. C. The possibilities of chewing tobacco and blended cigarettes in the Philippines. The Phil. Agr. 9–10: 7 (1928): 314–321.
6. PAGUIRIGAN, D. Wrapper leaf tobacco can be produced from native varieties. Com. and Ind. Jour. 6: 3 (1927): 4, 14.
7. RIDGWAY, R. Color standards and color nomenclature 3 (1912): 43 p. 53 Pl. Baltimore: A. Hoen Company.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Mechanical cigar smoker.

QUARTERLY NOTES

NOTES ON MOTTLE-LEAF AND ANTHRACNOSE FRUIT SPOT OF CITRUS IN BUKIDNON [1]

By MACARIO A. PALO

Assistant Plant Pathologist Bureau of Plant Industry

TWO PLATES AND ONE TEXT FIGURE

Mottle-leaf.—This is the most serious disease of citrus in Bukidnon. Although it is non-infectious, because of its non-parasitic nature, the disease appears rather general in nearly all the citrus orchards in fourteen settlement farm schools in Bukidnon. The disease can be recognized readily by the absence of chlorophyll in certain parts of the leaves between the main lateral veins (Plate 1, fig. 1). Of the commercial varieties of citrus commonly grown in Bukidnon, those which show the disease so distinctly are the sweet orange (*Citrus sinensis* Osbeck), the pummelo (*Citrus maxima* [Burn.] Merrill), and the mandarin (*Citrus nobilis* Lour), in the order of their enumeration.

In serious cases of the disease defoliation takes place, after which the twigs die gradually beginning from the tips (Plate 1, fig. 2). Usually after a severe dying-back of the twigs, numerous shoots spring up on the trunk and primary branches; but in trees thriving in impoverished soil, mottling of the leaves reappears and afterward defoliation and dying-back of the twigs take place again. Soon the affected tree dies. This disease caused the death of several citrus trees in Bugcaon and Kalasungay settlement farms and rendered about 40 trees in Alanib and 600 trees in Lantapan less productive, commercially. The marked decline of the yield in fruits of citrus orchards in other settlement farms has been attributed primarily to this disease.

Mottle-leaf is a physiological disease, the exact cause or causes of which have not been definitely determined. It is believed that it is due to certain abnormal conditions of the soil.

[1] Mottle-leaf and anthracnose spot are among the common citrus diseases found in a survey of Bukidnon during the early part of 1935.

Some conditions of the soil which are said to be contributory causes of citrus mottle-leaf are deficiencies of certain elements, inadequate supply of nitrogen, excess of nitrogen, lack of humus, toxic minerals in soils, and organic soil toxins.

The control of citrus mottle-leaf is also curious. While soil conditions are believed to be directly related to it, still their adjustments often fail to restore the health of trees seriously affected with it. Recently, it was found in California that this disease can be controlled more or less successfully by spraying with zinc sulphate applied either singly or in combination with lime or lime-sulphur. The results obtained with zinc sulphate-lime sulphur and zinc sulphate-lime hydrate have been claimed astonishing; however, no explanation was given why the mottled and depauperate yellow leaves became living green in a few weeks. For the control of citrus mottle-leaf in California, the best so far observed by experiment was light spraying with zinc sulphate-lime hydrate which was recommended by Parker[2] as follows: "For severe mottling, a spray of 10 lbs. zinc sulphate (about 25 per cent zinc) and 5 pounds hydrated lime to 100 gallons of water. For slightly or moderately affected trees, a spray of 5 lbs. zinc sulphate and 2½ pounds of hydrated lime to 100 gallons of water." To each of these spray mixtures should be added 4 ounces of powdered or liquid blood albumin as spreader before using.

For the control of citrus mottle-leaf in Bukidnon, the recommendations above should be tried with great caution under a wide variety of conditions. The treatment specified in the recommendation above should not be taken as a substitute for good fertilizer and general cultural practices. Since the soils in a number of citrus orchards, where mottle-leaf was general, have been found by chemical analysis to be highly acidic and deficient in calcium, potassium and phosphorous, the conditions of the trees may perhaps be improved by setting aright these soil deficiencies. Suitable cover crops such as ipil-ipil (*Leucaena glauca* [L.] Benth.) and other leguminous plants which do not harbor diseases and pests that attack citrus may aid greatly in improving the condition of the orchards.

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[2] Parker, E. R. 1935 Experiments on mottle-leaf by spraying with zinc compounds. The California Citrograph. *20*, No. 4, pp. 90, 106, 107. Figs. 1. 2.

Anthracnose fruit spot.—This disease is commonly found on pummelo fruits in Bukidnon. It was observed that it attacks the fruits in all stages of development, whether newly-set, (Plate 2, fig. 1) immature or mature. The affected fruits, especially the older ones, generally bear few lesions which are sunken, circular and of orange cinnamon color.[3] The incipient spots measure about 5 millimeters in diameter while the larger and older ones up to 40 or more millimeters. The spot is sometimes accompanied by an exudation of a clear, yellowish liquid which if not washed off by rain, hardens on the surface of the fruit (Plate 2, fig. 2), into a transparent mass, ochraceous-buff to ochraceous-tawny in color. Under favorable weather conditions pinkish masses of fungous fructifications, which sometimes appear in concentric rings, develop on the spots (Plate 2, fig. 3). During a prolonged drizzly or rainy weather the spots spread rapidly and may cover the entire fruits. On the other hand, prolonged dry weather inhibits the development of the spots and causes them to become hard and dry. On sectioning a number of badly affected fruits freshly picked from the tree it was observed that the disease attacks not only its rind but also its locules and core. Fruits which have been badly attacked by the disease fall off. The shedding of the fruits is frequently hastened by the invasion of maggots (larvae of fruit flies), beetles and other insects which enter through the rotted portions of the spotted fruit. Although common in Bukidnon, the anthracnose fruit spot disease has not been observed to be alarming in that place.

The disease is caused by the *Gloeosporium* stage (Fig. 1) of *Glomerella cingulata* (Stonem.) S. and v. s. The same organism is probably the cause of the blighting of avocado in certain places in Bukidnon.

The occurrence of anthracnose spot on pummelo fruits in Bukidnon seems to be related with the somewhat semi-temperate climate and with more or less abundantly uniform monthly rainfall in that region. In California the same disease was found favored by temperature ranging from 16 to 21°C.[4] This varia-

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[3] The colors indicated here are those of Ridgway's Color Standards and Color Nomenclature. Washington (1912).

[4] Fawcett, H. S. and A. Atherton Lee. 1926. Citrus disease and their control. First edition. McGraw-Hill Book Company, Inc. New York, 582 pp.

tion of temperature lies practically within the range existing in Bukidnon; hence, the prevalence of the disease in that place and its scarcity or absence in the warmer regions.

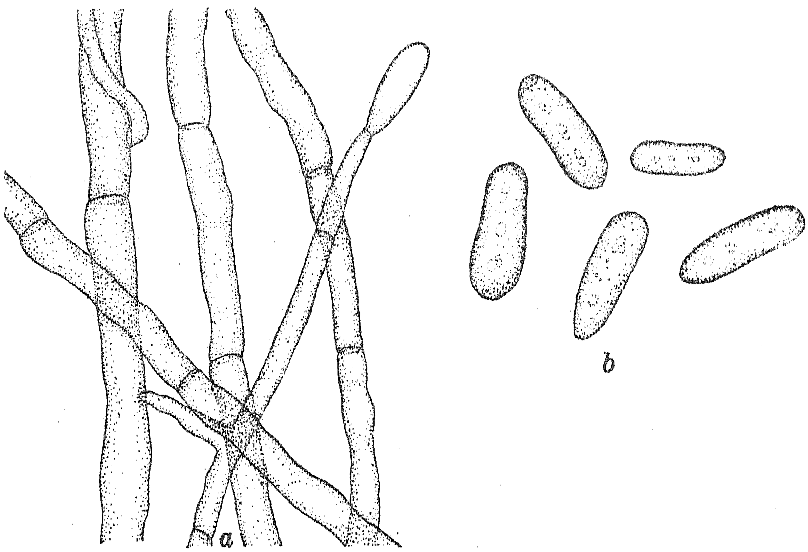

FIG. 1. Camera lucida drawings of mycelium (*a*) and spores (*b*) of anthracnose spot organism on pummelo fruit.

Since the anthracnose spot disease occurs usually on fruits of weakened trees, greater attention should, therefore, be directed to the growing of vigorous trees. In controlling this disease the first thing that should be done is to eliminate the sources of infection by picking the dried or diseased fruits and twigs and then burning them. Serious infection of the fruits may be prevented by spraying the trees three times with Bordeaux mixture (Bluestone, 2 kilos; quick-lime, 2 kilos; water 200 liters); first, immediately before flowering; second, when most of the fruits have set; third, 3 weeks after the second application.

ILLUSTRATIONS

PLATE 1

FIG. 1. Mottled leaves of sweet orange. Note the chlorotic parts of the leaves between the lateral veins. About ¾ natural size.

2. An advanced case of mottle-leaf on sweet orange. Note defoliation and dying-back of the twigs. About X 1/18.

PLATE 2

FIG. 1. Newly-set pummelo fruits attacked by anthracnose spot. Note the growth of anthracnose spot organism which covers the entire fruit. Slightly more than natural size.

2. Anthracnose spot on premature pummelo fruit. Note the exudation oozing out of the spot. About natural size.

3. A premature pummelo fruit attacked by anthracnose spot. The spots are covered with masses of mycelium and spores of the causative fungus.

TEXT FIGURE

FIG. 1. Camera lucida drawings of mycelium (*a*) and spores (*b*) of anthracnose spot organism on pummelo fruit. About X 1600.

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2

PLATE 1.

1

2

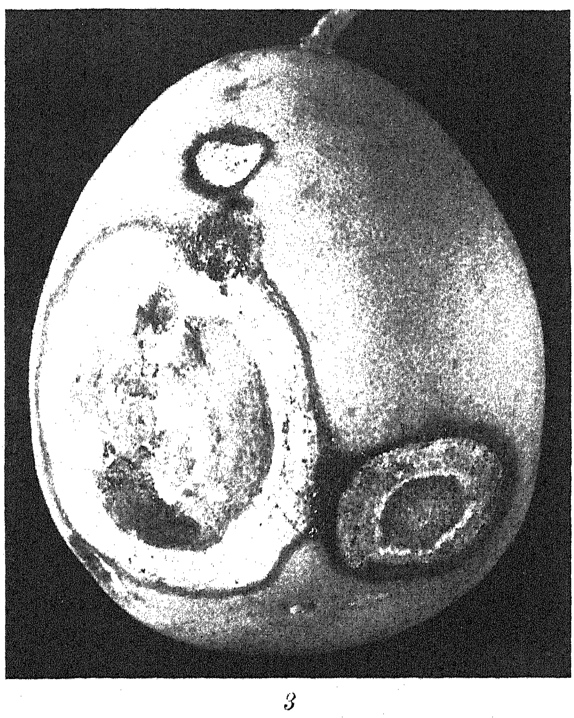

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PLATE 2.

THE IDENTITY OF THE COTTON STEM WEEVIL AND PARASITES OF THE CATERPILLAR OF *COSMOPHILA* AND THE COMMON MEALY BUG [1]

By F. Q. OTANES

Of the Plant Pest and Disease Control Division
Bureau of Plant Industry

In a paper on cotton insects (Otanes and Butac: A preliminary study of cotton insects in the Philippines and suggestions for their control) in a previous issue of the Philippine Journal of Agriculture (Vol. 6, No. 2, 1935, pages 159 to 160, Plate 1, figs. 2 and 3) it was stated that the cotton stem weevil was apparently similar, if not identical, to another species, *Phylaitis* sp., which occurs in India and described and figured by Lefroy and Howlet (Indian Insect Life, 1909, p. 389, pl. 27). The weevil was recently identified as *Pempheres affinis* Faust, by Mr. L. L. Buchanan of the U. S. Bureau of Entomology and Plant Quarantine, from specimens sent to Dr. H. Morrison, in charge of the Division of Insect Identification of that Bureau. Mr. Buchanan called attention to the fact that the species also occurs in India and was reported in the Science Reports (page 68, 1928–29) of the Pusa Agricultural Research Institute. The species is listed by W. Schultze in his catalogue of Philippine coleoptera (A Catalogue of Philippine Coleoptera, 1915, Bureau of Science, Manila), based on material collected at Los Baños, Laguna, by the late Dean C. F. Baker (17334, Baker). In this connection it may be stated that a letter has been received from Mr. M. C. Cherian, Government Entomologist, Coimbatore, South India, saying that *Pempheres affinis* Faust is rather serious to cotton there. He added that some hymenopterous parasites have been reared from the weevil in India and inquired whether parasites of the species have been observed in the Philippines. So far as known, no parasites have been reared locally as yet from this species. Because of the fact that the larvae work in the stems of cotton plants, the insect would be very difficult to control should it become prevalent in a locality. The weevil is therefore worthy of detailed study.

The hymenopterous parasite of the caterpillars of *Cosmophila erosa* Hubn., described and referred to as *Euplectrus* sp. in the

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[1] Read before the Third Philippine Science Convention, held at Manila in March, 1935.

same paper (page 154, Plate 10, figs. 1 to 4) was identified as *Euplectrus manilae* Ashmead, by Mr. A. B. Gahan of the U. S. Bureau Entomology and Plant Quarantine from specimens sent to Dr. Morrison. Mr. Gahan has also identified the three species of parasites of the common mealy bug, *Ferrisia virgata* Ckll., (page 162), as *Leptomastix longipennis* Mercet, *Holanusomyia pulchripennis* Girault, and *Blepyrus insularis* Ashmead.

ERRATA

VOLUME 6, NO. 3

Page 272, first paragraph, fourth line. Read *ovales* instead of *vales.*

Page 273, first paragraph, eighth line. Omit comma (,) between the words breadth index.

Page 278, third paragraph, fourth line. Read *curly* instead of *surly.*

Page 281, second paragraph, fifth line. Read *both plots* instead of *both dots.*

Page 283, first line. Read *marked* instead of *market.*

Page 283, second paragraph, tenth line. Insert *coarse* to read *and these are coarse to be considered as wrapper leaves.*

Page 283, second paragraph, twenty-fifth line. Change *plus* (+) sign to *division* (÷) sign.

Page 284 and page 285. All *plus* (+) signs and *multiplication* (×) signs between figures in the table should be changed to *plus* and *minus* (±) signs.

Page 287, footnote (1) *EE* change to *FE*, being abbreviation for fairly erect in the table.

Page 287, footnote (2) *Swo* change to *Sw*, being abbreviation for swollen in the table.

Page 289, fourth and fifth paragraphs. All *plus* (+) signs between figures should be changed to *plus* and *minus* (±) signs.

Page 289, fifth paragraph, sixth line. *Hx*F4-14 should be changed to *Ix*F4-14.

Page 290, all *plus* (+) signs between figures should be changed to *plus* and *minus* (±) signs.

Page 303, table heading. Read *computed* yield instead of *completed* yield.

Page 306, third line. Read *strain tests* instead of *certain tests.*

Page 307, seventh paragraph, first line. Read *selections* instead of *selection.*

Page 307, seventh paragraph, third line. Change *this* to *these.*

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